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MATHEMATICS.—*Information theory.*[1]

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Information theory deals with the communication of information without regard to any psychological or semantic "value" assigned to messages. The value measure of a message is ignored from necessity, not from choice. We are forced to assign a numerical measure to a message with reference to a class of messages. For example, a sentence can be considered as a member of a class of messages consisting of all possible sequences of letters and spaces of the given length. Most of these permutations would be meaningless as English text but could be assigned arbitrary code meanings in general. We shall assign a mathematical measure of the information in each that completely disregards any assigned meaning.

We could define the information content of a message in terms of its length, i.e., the number of letters or telegraph symbols it requires for transmission. This turns out to be inappropriate, for most messages contain redundancy and can be uniquely communicated by fewer characters. This suggests using the minimum sufficient character count as a measure of the information. To standardize this idea, let all messages be thought of as coded into binary form, so as to be transmitted by a sequence of dots and dashes, heads and tails, or zeros and ones. The information measure of a message in "bits" (binary digits) will be taken as the number of binary digits absolutely needed to distinguish this particular message from all others of the class considered. One such class might be all 50 character sequences of the 27 symbols of English (26 *letters* and *space*). Let us deal with an example.

[1] A lecture delivered before the Philosophical Society of Washington, December 15, 1950.

For simplicity, reduce the alphabet to 16 characters (including *space*) and consider all possible messages of 35-character length. One member of this class is: THIS IS CERTAINLY A TRIVIAL EXAMPLE. Each of the characters of our short alphabet can conveniently be represented by a unique combination of four binary digits, since there are exactly $2^4 = 16$ such combinations. This requires $4 \times 35 = 140$ binary digits to represent the whole message.

The message can, however, be coded for more efficient transmission. Instead of using four binary digits for each character, consider using only three for each of the more frequent characters, at the expense of using five for those less frequent. There is a net gain, as we shall see. Let us tabulate the characters in the order of their frequency. An efficient coding is given in Table 1.

When the message is coded by four digits per letter, the sequence of digits (no spaces!) can be uniquely decoded by dividing it into groups of four, and decoding each group.

TABLE 1

Character	Count	Representation	Total digits
Space	5	000	15
I	5	001	15
A	4	010	12
E	3	011	9
L	3	1000	12
T	3	1001	12
R	2	1010	8
S	2	1011	8
C	1	11000	5
H	1	11001	5
M	1	11010	5
N	1	11011	5
P	1	11100	5
V	1	11101	5
X	1	11110	5
Y	1	11111	5
Average = 3.74 binary digits/letter			131

With our more efficient coding, the message starts as follows: 1001110010011011 · · · . How are the digits to be grouped for decoding? An examination of the representations in Table 1 will show that the decoding is unique, for no shorter group forms the first part of any longer group.

If it is desirable actually to transmit the message in terms of the literal characters rather than binary characters, the sequence of 131 binary digits can be arbitrarily divided into "fours" and each of these groups coded as one of the 16 letters by an arbitrary assignment of the combinations. The 131-digit message can then be transmitted by 33 characters of the original alphabet, instead of the 35 characters needed for straight transmission. At the receiving end these characters are replaced by the 4-digit groups, and the resulting sequence decoded by Table 1.

The digit code that we set up as efficient for our particular message will, of course, be very inefficient for certain other messages. We really wish the coding scheme that is most efficient on the average for the whole class of messages considered. This can be found by using the relative frequencies, or probabilities, of the letters in the whole class of messages, rather than in a particular message. For example, consider the class of messages made up of our 16-letter alphabet, with the individual letters having the probabilities given in Table 2. The total probability is 1. In fact, these percentages are the same as in Table 1, intentionally. Thus if Table 1 represented the relative occurrence of the letters in the whole class of messages considered, the corresponding code would be efficient and would allow the use of 3.74 digits/letter averaged over all messages of the class, weighted by the probabilities of the various possible messages.

With reference to a particular class of messages, we can define the information measure of any particular message as the number of binary digits needed to code the particular message, *using the code that is most efficient for the class as a whole*. The average information per message of this class will be the average number of digits per message, using this code. There is a formula for this average information.

To arrive at the general formula, consider a "perfect" case, one in which each successive binary digit of the code distinguishes between equally likely alternatives. Such is illustrated by a 5-letter alphabet, with the probabilities and representations shown in Table 3.

The average number of digits per character is

$$\tfrac{1}{2} \cdot 1 + \tfrac{1}{4} \cdot 2 + \tfrac{1}{8} \cdot 3 + \tfrac{1}{16} \cdot 4 + \tfrac{1}{16} \cdot 4 = 1\tfrac{7}{8}.$$

Note that this expression is

$$p_1 \log_2 \frac{1}{p_1} + p_2 \log_2 \frac{1}{p_2} + \cdots = \sum p_i \log \frac{1}{p_i} = -\sum p_i \log p_i$$

where the logarithms are taken to the base 2. It can be shown that this is a best possible case, and that for any scheme, the average number of digits per character satisfies the relation

$$n \geq -\sum p \log p \equiv H.$$

In our example of Table 2, we have $n = 3.74$ binary digits/character compared to $H = 3.71$. The average information per message in this case is 3.71 bits/character. For any given transmission rate of elements, the information rate can be expressed in bits per second.

Consider the ensemble of all messages composed of these 16 letters with the given

TABLE 2

Character	Probability
Space	0.143
I	0.143
A	0.114
E, L, T	0.086 each
R, S	0.057 each
C, H, M, N, P, V, X, Y	0.0285 each

TABLE 3

Character	Probability	Code
A	$p_1 = \frac{1}{2}$	0
B	$p_2 = \frac{1}{4}$	10
C	$p_3 = \frac{1}{8}$	110
D	$p_4 = \frac{1}{16}$	1110
E	$p_5 = \frac{1}{16}$	1111

relative frequencies; i.e., successive letters independently chosen with the respective probabilities. In a long message of N characters, the first letter will occur p_1N times (on the average), the second p_2N times, etc. The probability of any particular sequence of this length is

$$P = {p_1}^{p_1N} {p_2}^{p_2N} \cdots {p_{16}}^{p_{16}N}$$

which can be simplified by taking logarithms:

$$\begin{aligned} \log P &= p_1N \log p_1 + p_2N \log p_2 \\ &\quad + \cdots + p_{16}N \log p_{16} \\ &= N\Sigma p_i \log p_i = -NH. \end{aligned}$$

Since H was earlier found to be the average information per character, the total information for N characters is $I = NH = -\log P = \log 1/P$. Thus the information in a message is measured by (minus) the logarithm of the probability of sending this particular message of the ensemble.

This result has a certain intuitive justification. If the Archbishop of Canterbury tells you that he believes in God, he conveys little information. You expect him to say this. That is, this "message" is much more probable than its opposite. If, however, he should tell you that he doesn't believe in God, you would attach considerable weight to his statement. It is a very improbable statement, so he must have thought about it carefully before making it!

Let us return to the information formula $I = -\log P$ and apply it to a very short message of one character. If this is the i^{th} character, it carries the information

$$I_i = -\log p_i$$

The average information per character is then the average value of I_i weighted by the probability of the i^{th} character, or

$$\sum p_i I_i = -\sum p_i \log p_i = H$$

as before. It is easily shown that the average information per character (H) is maximized by making all p_i equal, with the result

H_{max}
= log (number of characters in alphabet).

It has been said that "one picture is worth a thousand words." This can be roughly analyzed mathematically. Consider for simplicity all possible 5-letter words made up of 26 characters chosen with equal probability. This is a very crude approximation to English but will serve for the illustration. The average information per letter will be $H = \log 26 = 4.7$ bits/letter. A thousand words will carry on the average 23,500 bits of information. Now consider the picture as consisting of 10,000 square elements (100×100) independently darkened to different shades of gray. How many shadings must be available for the picture to carry our 23,500 bits of information? Each element must carry 2.35 bits, or the logarithm (to the base 2) of the number of available shades must be 2.35. This yields 5.1 shades, a physically absurd answer. We conclude that five shades will carry almost enough information, six will give more than needed.

The general theory of communication is based on the probability concepts we have been discussing. To an engineer a communications "source" might mean a broadcasting station, a phonograph record, or some other physical entity. In the mathematical picture, the source is the ensemble of messages to be handled, that is, a class of messages with assigned probabilities. A communication system is not designed to handle particular messages, but to handle a whole class of messages with the best *average* reliability. The class of messages may be of infinite number, with the probabilities described in terms of a random process for generating successive elements of a message.

With the element probabilities given, and the elements independently chosen, the average information per element, $H = -\Sigma p_i \log p_i$, can be thought of as the average uncertainty of the generating process. If the elements are generated at the rate of N per second, we can speak of the average uncertainty rate, $-N\Sigma p_i \log p_i$, as the average rate at which information is generated and transmitted. By analogy with statistical mechanics, the average uncertainty is called the "entropy" of the source. Hence we describe a source in terms of its entropy rate. We shall denote this by $H(x)$, the x referring to the source. If the messages generated by the source are received as sent, the rate at which information is received or communicated is obviously the same as the

rate at which it is sent. This can be expressed by the fact that reception has completely removed the uncertainty as to what message was sent. If, on the other hand, messages are corrupted in transit, some information is lost. We can say that there is a residual uncertainty not removed by reception, or that the reduction of uncertainty is less than the original uncertainty. A natural definition of the amount of information received is "the reduction, due to reception, of the original uncertainty of what was sent." Dividing by the time for communication, we obtain the *rate* of communication of information. Letting $H(x)$ denote the original uncertainty of the source, and $H_y(x)$ the residual uncertainty, i.e., the uncertainty when the received message (y) is known, we have for the rate of communication:

$$R = H(x) - H_y(x).$$

This can also be interpreted as:
(Average rate of sending information) minus
(Average rate of losing information).

Similarly let $H(y)$ denote the uncertainty of the corrupted message to be received, and $H_x(y)$ the irrelevant uncertainty introduced by the source of corruption, the noise on the communication channel. The symbol $H_x(y)$ indicates the uncertainty of the received message (y) *when the sent message* (x) *is known*. We can consider $H_x(y)$ as the "false information" in the received message, so that the net rate of receiving (intended) information is:

$$R = H(y) - H_x(y).$$

The two expressions for R can be combined to yield the following expression for the loss of information, or residual uncertainty of the message:

$$H_y(x) = H(x) + H_x(y) - H(y).$$

The three terms on the right are, respectively: (1) The uncertainty of the source; (2) the uncertainty of the perturbations; and (3) the uncertainty of the result. It can be shown that $H(x) + H_x(y) \geq H(y)$, the inequality arising when some of the uncertainty of the changes duplicates some of the original uncertainty. Hence the loss of information equals the loss of uncertainty or lack of additivity in the mixing process. This effect is similar to the increase of entropy occurring in the mixing of isotopes.

For a given communication channel, that is, given corruption effects $H_x(y)$, the statistics of the source can be adjusted to maximize the rate of communication. This is the statistical analog of impedance matching. The maximum rate so obtained is called the *capacity* of the channel. It was shown by Claude Shannon, of the Bell Telephone Laboratories, that any source generating information at a rate $R \leq C$ can be so encoded as to be communicated over any channel of capacity C with an arbitrarily small error. A special example will serve to illustrate this remarkable theorem.

Consider a channel handling binary digits and making not more than one error per block of seven digits. We shall see how to encode a message so as to transmit it over this channel with absolutely no errors.

Associated with each block of seven digits are eight error possibilities: no error, and seven possible error locations. These eight cases can be identified by three binary digits. Let the case of no error be arbitrarily called an error in position zero. Then the possible error positions can be identified by the following code:

Error Position	*Identification*
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

The last four error positions are distinguished by an initial 1 in the code. A scheme for automatically generating a 1 in case the error is in one of these positions would eliminate half the possibilities. Similarly, automatic schemes for determining the other two binary digits would result in complete location of the error. Since the information is being transmitted by binary characters, location of the error allows correction of the error, since there are only two different characters. Such a scheme has been devised. Let the seven digits of the

message block be denoted by $x_1, x_2, \cdots x_7$. If these digits are such that

$$x_4 + x_5 + x_6 + x_7 \equiv 0 \pmod 2,$$

that is, if there is an even number of 1's among these four, then changing any one of these will make the sum $\equiv 1 \pmod 2$. Thus if the error occurs in position 4, 5, 6, or 7, the distinguishing 1 will be generated. Similarly, the second digit of the error identification can be found if the transmitted digits x_2, x_3, x_6, x_7 are so related that

$$x_2 + x_3 + x_6 + x_7 \equiv 0 \pmod 2.$$

The last digit is determined by initially specifying

$$x_1 + x_3 + x_5 + x_7 \equiv 0 \pmod 2.$$

In these three conditions, the digits x_1, x_2, x_4 appear singly and separately, so these three digits can be chosen to satisfy the conditions, no matter what x_3, x_5, x_6, and x_7 may be. The latter four can be chosen arbitrarily, i.e., used to carry information, and the other three adjusted to meet the conditions.

For example, suppose we wish to send the message 1011. Then $x_3 = 1$, $x_5 = 0$, $x_6 = 1$, $x_7 = 1$, and we must make $x_1 = 0$, $x_2 = 1$, $x_4 = 0$ to satisfy the three conditions. The sequence transmitted is 0110011. Now suppose the fifth digit is changed in transmission; we receive 0110111. What was sent? Testing by the first condition, we find $x_4 + x_5 + x_6 + x_7 \equiv 1 \pmod 2$, i.e., an odd number of ones among the last four digits. The first digit of the error identification is therefore 1. The second condition gives

$$x_2 + x_3 + x_6 + x_7 = 1 + 1 + 1 + 1 \equiv 0 \pmod 2,$$

and the third one gives

$$x_1 + x_3 + x_5 + x_7 = 0 + 1 + 1 + 1 \equiv 1 \pmod 2.$$

The error is therefore identified by 101, which refers to position five. We change the fifth digit and have the original message.

In practical communication, we are more concerned with information represented by continuous functions than by discrete sequences. Telephony utilizes a voltage wave, for example, and direct speech an acoustic pressure wave. Unfortunately the statistical mathematics dealing with ensembles of random functions is very complex. I can do no more here than to present briefly some of the results in this field.

The characteristics of an ensemble of continuous functions are described partly by a statistical term, and partly by the power spectrum, or distribution of the power versus frequency by Fourier analysis. It has been found that the worst kind of noise has a so-called Gaussian statistical distribution, and that the best source for combatting such noise has also a Gaussian distribution. My remarks will therefore be confined to this case. Analysis shows that the best power spectrum for the source, i.e., the best distribution versus frequency of the total source power, is such that the received signals have a "flat" spectrum. That is, the received power should be uniformly distributed over the frequency range used. This means that the source spectrum should be complementary to the noise spectrum, we try to send more message where there is less noise, and vice versa. This result agrees with the familiar pre-emphasis techniques of frequency modulation and some recording processes. With this complementarity satisfied, we achieve a channel capacity that can be expressed as

$$C = W \log \left(1 + \frac{P}{N}\right)$$

where W is the width of the frequency band used, P is the total signal power in this band, and N the noise power. This fundamental relation shows how bandwidth may be traded for power, or vice versa, and has had engineering applications.

ETHNOLOGY.—*Utilization of animals and plants by the Micmac Indians of New Brunswick.*[1] FRANK G. SPECK,[2] University of Pennsylvania, and RALPH W. DEXTER, Kent State University. (Communicated by John C. Ewers.)

In the summer of 1949 the writers went in search of further information on the utilization of animals and plants by American Indians, continuing the studies already published (Speck and Dexter, 1946, 1948). We were fortunate in finding near Limington, Maine, Mr. and Mrs. Louis Francis, who had come from the Micmac band at Richibucto, New Brunswick. They are familiar with the hunting and fishing activities in their native region from their own experience and through contacts with older people there, and to them we are greatly indebted for their unstinted cooperation in this ethnoecological study. We were able to learn from them the principal animals and plants that have been utilized, especially those used for food. Most of such practices have been handed down from ancient days. This investigation centered around food and its procurement, but other uses were brought out incidentally, particularly the multiple uses of certain food organisms, and such information is included in this report. Information from our informants has been correlated with the archeological, ethnological, and biological publications on the region. Medical use was not investigated, since that is a special study in itself and some material has already been published on that subject (Hagar, 1896; Speck, 1917; Wallis, 1922; Stone, 1932).

The culture of these Northeastern Indians has always tied them close to nature, since originally they depended almost entirely upon the harvest of natural resources. Even today this relationship persists. Modern economic life still consists largely of fishing, trapping, hunting and serving as hunting guides, lumbering, and splint-basket weaving. Agriculture has developed extensively only within historic time. Undoubtedly two important reasons why agriculture did not develop to a high degree were the poor soil and the short growing season which imposed limitations (Hadlock, 1947a). This is a good example of the way in which environment determines economic development. Wissler (1926) has pointed out that "students of culture are well agreed that the objective forms taken by aboriginal tribal cultures are determined by the features of the environment to which native life has been adjusted." Sears (1932), writing about the environment of the Northeast in general, has explained that "the vigorous growth of forest, abundance of fish and game, rigorous winters, and tendency of much of the land when cleared to become acid were in no sense, at any time, a stimulus to agriculture." Native animal life, on the other hand, permeated the entire life of the Micmac culture. Their rich folklore, of which much has been recorded, is largely concerned with hunting and fishing activities, or involves animals of the chase, and their magico-religious beliefs centered around animal spirits. Art was expressed chiefly on the skins, bones, and teeth of animals. A significant portion of their social organization was concerned with the family hunting territory system. Their housing and clothing at one time were made largely from animal skins. Some of their native medicines were derived from animal products. Their food consisted chiefly of the spoils of fishing, hunting, and trapping pursuits of the men. Such activities took place along the seashore, in the tidal inlets and saltwater ponds, rivers, marshes, bottomland swamps, and in the forests of mixed conifers and hardwoods and their glades. This animal diet was supplemented by the gathering of fruits, berries, nuts, seeds, roots, and similar plant products by the women. Little, if any, cultivation was practiced, al-

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[2] In the course of preparing this study for publication, Dr. Speck passed away on February 6, 1950. Through the kindness and efforts of Mrs. Frank G. Speck and John Witthoft, Pennsylvania Historical Commission, Harrisburg, it was possible for the junior author to complete the manuscript very nearly as it was originally planned. Mr. Witthoft is responsible for the transcription of the phonetic forms from Dr. Speck's field notes, and any errors present are due to misinterpretations of his handwriting, which suffered with his failing health. Valuable suggestions were made by Mr. Witthoft and by Ernest S. Dodge and Wendell S. Hadlock, of the Peabody Museum, Salem, Mass., all of whom read the manuscript critically.

though in protohistoric times planting of maize, squash, and beans was carried out.

Let us enumerate, then, the principal wild animals and plants which have been utilized by the Micmac for food with special reference to the coastal band at Richibucto. Admittedly, a complete study can not be made with the information from two informants, but certainly the most important natural food products would come to the attention of those who have lived in the community under investigation. Our own notes have been supplemented with gleanings from published accounts. Originally it was planned to prepare a table of organisms known to be used by the Micmac with a column for the native names used by this group of Indians. This was not completed before the death of Dr. Speck. John Witthoft has since transcribed the phonetics recorded by Dr. Speck in the field for use by the writer. We discovered that a complete list of names was not made, as Dr. Speck undoubtedly depended upon memory for those Indian words well known to him. For this reason, Table 1 was not completed as planned, but in each case where the Indian name was recorded, it is given in the text. This investigation was approached through a synthesis of the special interests of the collaborators. The ethnological phases were handled by the senior author, who often conversed with the informants in their native dialect, while the biological and ecological phases were handled by the junior author. A similar report on the Malecite Indians of the St. John River Valley of New Brunswick, investigated at the same time, will be published at a later date.

THE COASTAL MICMAC INDIANS OF RICHIBUCTO

The Micmac Indians of coastal Nova Scotia and eastern New Brunswick have long attracted the attention of anthropologists. The prehistoric culture of these northeastern shore dwellers, so far as it is known, has been described through the archeological papers of Jones (1864), Patterson (1889), Piers (1895, 1912), and Smith and Wintemberg (1929). Ethnological descriptions have been given by the early travelers, visitors, and clergymen who lived among the Micmac, particularly in the writings of Maillard (1758), Rand (1850), Elder (1871), Hagar (1895), Chamberlain (1904), Denys (translated by Ganong, 1908), Le Clercq (1910), and Lescarbot (translated and reprinted, 1928). Modern scientific studies have continued to chronicle the culture of the survivors of these neolithic hunting and fishing people in such publications as those of Speck (1922), Flannery (1939, 1946) and Cooper (1946). Micmac folklore has been recorded by Leland (1884), Rand (1894), Alger (1897), Prince (1906), Speck (1915a), Parsons (1925), and Michelson (1925).

The Micmac Indians long depended upon marine resources for food, especially during the summer months. Probably the great majority of this tribe lived on or near the coast; Le Clercq (1910) pointed out that the summer months were spent at the seashore where fish and meat were dried and smoked for winter use. Those living at Richibucto at the mouth of the Richibucto River obtained much of their subsistance from the marine resources of Big Cove. Marine life played a very important part in the economy of these seashore dwellers. The mollusks, particularly, were utilized. Ganong (1889) many years ago wrote that "the most valuable to man by far, in all the groups of invertebrates, is that of the Mollusca. In all parts of the world, savages and civilized men have utilized its members." In his monograph Ganong gives a complete list of mollusks that have been used by the inhabitants of Acadia. Further information is available in the reports on shell heaps which have been excavated in the region. These give mute evidence that the shelled animals especially were harvested by the Micmac over a long period of time, and that they formed the great bulk of the diet of these Indians during the warm months of the year. In the mud flats during periods of low water the soft-shell clam (ɛs) is easily available. Its tenderness and flavor have made it a favorite as a food mollusk by all groups of mankind living within its range. Shells of this species make up a large percentage of the shell mounds.

The razor clam was also dug from the mud and sand flats although not in such abundance as the soft-shell clam. In mussel beds over the tidal sediments and on rocky shores the blue mussel grows in abundance. Lescarbot, writing in 1609, is quoted by Ganong saying, "The Micmac have a superstition, not to wish to eat mussels (*M.*

edulis), yet they cannot give a reason for it—nevertheless, in our company, seeing us eat them, they did likewise." The number of blue mussels in kitchen middens, however, would indicate that at one time it was a popular item of food. Attached to these mussel beds, and on the rocks of the lower shore line, live the boat shells or slipper shells, which have long been considered a delicacy by the North American aborigines of the Atlantic coast. Along the exposed shore at times of perigee tides, the sea clams or hen clams were gathered. These were boiled and made into a stew. The shells have been used in recent times for decoration about homes and gardens. In the shallow waters of the inlets and salt-water ponds the quahog has been collected in abundance. Besides being an important item of food, the shells were used as a source of purple wampum. Piers (1912) quoted Lescarbot making the claim that wampum was obtained by barter with the New England Indians. How much actual manufacture of wampum beads (Kwayo'psu) was carried out by the Micmac is not known although the quahog shells were available to them. Today, however, the quahog is only rarely found between Cape Cod and the Gulf of St. Lawrence. Wampum among the Micmac was used for ornaments and ceremonies rather than money. Denys (1908) mentions that the wampum beads were originally strung on tendon removed from the spine of a moose. A Micmac wampum belt is described and illustrated in Bulletin 4 of the Free Museum of Science and Art of the University of Pennsylvania (author not given). This belt is an example of the use of wampum for symbolic purposes and is believed to commemorate the friendly alliance of two Christian communities among the Indians. This type is sometimes called a "missionary belt."

Another valuable shellfish is the oyster (mɑ'ndɑmu(-x pl.)). Again, oysters are no longer found in any significant abundance between Cape Cod and the shores of eastern New Brunswick on the Gulf of St. Lawrence, although they are abundant in many prehistoric shell heaps in the intermediary area. With the coastal Micmac, however, this bivalve mollusk was nearly as important as it was to the Wampanoag of southern Massachusetts. Quantities of oyster shells have been found in refuse heaps in both places. Ganong (1889) places this mollusk first in importance although shell heap studies in Micmac territory do not always indicate this to be true. Often, shells of the soft-shell clam are far more numerous. Ganong probably based his appraisal on the use of the oyster over a long period of time, with special reference to use in recent times. Besides being an important item of food, oyster shells were used to polish wood for their bows, according to Denys (1908). Scallops are listed by Ganong as the third most important group of mollusks utilized in the New Brunswick area. The horse mussel and two snails, the sand-collar snail and the English whelk, were also used according to the findings in refuse heaps, although Mr. Francis did not know of their being used in recent times. Shellfish at one time were a very important part in the economy of the coastal Micmac. They were used for food, bait, ornaments, and for temper in the manufacture of pottery. Pottery was often made by these people, but their efforts were very crude. Sea shells were powdered for use as temper in some of the pottery they did make. Piers (1895) has described the use of seashells as ornaments fastened to the ears, neck, bodies, arms, and legs of the Indians.

Shells of all species mentioned above have been found in refuse heaps excavated in Micmac territory except the razor clam. Mr. Francis did not know of its use, but Cooney (1832) and Denys (1908) listed it among others eaten by these people. Shells of several small species of snails (e.g., *Thais lapillus* and *Urosalpinx cinereus*) have also been identified, but probably these were gathered incidentally, especially the latter species which is the oyster drill, a predatory snail, commonly found feeding on the oyster.

Fowler (1871) has called attention to the fact that many shell heaps have been washed out by the sea. Undoubtedly many such deposits have been destroyed in the past. Smith and Wintemberg (1929) found many shells that had been used for food but did not discover any implements made from the shells nor did they find any wampum. They found three shells of *Cepaea hortensis*, a land snail (mi'ktcick). This species has been thought by some zoologists to be a European introduction. Its discovery in Indian shell heaps is, therefore, of notable interest. Its use by the Indians, if any, is questionable. Also, the snails may have burrowed or been carried underground by animals in recent times.

Squids were at one time commonly eaten. Denys (1908) described the method of capturing them as follows. During a rising tide (we'tckaba'x) a bonfire was built on the shore. Squid, attracted

by the light, swam into shore and were stranded on the beach as the tide went down. Other invertebrate foods from the sea (ɑkᵉta'ʔan) include the lobster, the rock crab (indjindja'ges), and shrimp (tca'gadji·tc). The lobster was captured with a spear. According to Denys (1908) lobster claws were used as pipes. The crabs and shrimps were used as bait as well as food. Lescarbot, writing in 1606, and Cooney (1832) both list sea urchins and Cooney also mentions starfish among food items, but no other evidence is available on the use of these echinoderms by the Micmac. No evidence was uncovered from any source that the horseshoe crab had any part in the economy of these maritime people although it is known to have been used along the New England coast for many purposes.

Marine vertebrate animals were also of great importance. Seals (wa'spux) were hunted for food, hides, and oil. The oil was used in cooking, for fuel, and to grease the hair. Seal oil was a delicacy at their feasts. Seal skins spread over needles of the fir tree were used for bedding. While the walrus is now extirpated in this region, it was hunted in former times as indicated by tusks found in the refuse heaps. The ivory was used in the manufacture of such objects as harpoon points and the dice used in the game known as "Indian Dice," according to Piers (1912). It is believed that the Micmac traded ivory to the Penobscot tribe in Maine. Whales (po'dɑp) and porpoises (mospe'tc) were obtained whenever found stranded on the shore or were harpooned from drift boats. In addition to the use of the oil and meat, the ribs were used for bark peelers and wedges (Smith and Wintemberg 1929). Sea turtles (miktciᵏtc) were similarly captured and utilized. The marine fish were of special importance and have continued so to the present day. Smelt (ga'xpesaw) is the first to appear in the spring followed by the herring (Denys 1908). Smelt were captured by the placing of hurdles across a brook to trap the fish in the head waters (Lescarbot 1928). According to Mr. Francis they were also taken on a fishing line. The herring and their young, known as sardines, were eaten in large quantities. They were also used for fertilizer. Mackerel (hámɑnɑ'n), capelin, and a species known to Mr. Francis as the salt-water sunfish (nago'sit nɑme'tc) (which the writers do not recognize), were similarly obtained for use. Fish of the sea bottom which have been utilized are the flounders (ana'gwetc), halibut (psa'nakʷ), cod (pɛ'dju), haddock, Norway haddock (now known as rose fish or redfish), cunner, sculpins (mɑ'ndowe nēmɛ'tc), skates (tekɑna'lowi·tc), and dogfish (ɑ'lɑmutc name'tc). These demersal fish were obtained by spearing in shallow water as well as by nets and hook and lines. Oil from the liver of codfish and the flesh of redfish were of economic importance to the Indians long before these became of commercial importance to white man. Jones (1864) suggested that the opercular spines of redfish found in shell heaps were used as an awl for punching holes. Mr. Francis does not know of the dogfish or sculpin being used for food in recent times.

The Micmac employed many devices for obtaining aquatic resources. These included spears (ni·gɔk), harpoons with points made from bone or walrus ivory, hook and line (mʔki·gana'tkᵉ) made from hemp with fishhooks (mᵉki'gan) of bone, fish nets (ābi·) with stone sinkers, dip nets (nʔha'ni·ganabi), and fish weirs with a bag net. Fish pounds (hɑluda'ʔan) were made to trap the ocean fish in an enclosed basin where they could more easily be captured.

Entering the rivers are a number of anadromous fishes that were sought by the Indians. Included were the sturgeon, Atlantic salmon (nigɔ'k), shad (apsa'mu), striped bass (ɛlta'Xte), white perch (wa'pet dja'xtedji·tc), tomcod, and the sea lamprey. Most of these were speared at night with the aid of a birch-bark torch. This was particularly true of the sturgeon and salmon. There is only one species of salmon on the Atlantic coast. Our informant spoke of three different types, the "black," "bright," and "hooked-bill salmon." It is clear that what he believed to be different species were merely variations in color and a difference in sex. The male Atlantic salmon has a protruding lower jaw which has given the name hooked-bill salmon to this sex. Salmon were pursued particularly in June. The method of torch fishing is vividly described in the words of Dr. Speck as follows:

"Of equal importance in the taking of fish is a method known as 'torch fishing' in use among peoples throughout the forest area of the entire Northeast. Torch fishing (Sɛksi·gwe') is resorted to at night by two men who man a hunting canoe (kwi'·dɑn) which is driven to the base of waterfalls where in the North salmon congregate in the spring-run ready to ascend to their spawning beds. The canoe is managed by the steersman whose job is to direct the boat where the man in

the bow tells him. The bowman is the actor in this night drama of food getting and sport—for sport it also distinctly is in the minds of the Northern Indians. The bowman is armed with a double bracketed fish spear or leister. With this type of spear he is able to impale large fish which swim within range of his light. Now let us examine this light which gives the distinct character to this method of taking fish. It consists of a bundle of folded birch bark several feet in length and some inches in thickness tied firmly with splints of basswood and fastened into the cleft of a pole fastened in the bow of the canoe. The torch pole is tilted over the water. When ignited this torch, or flambeau, illuminates a wide space at the side of and at the head of the canoe in which swimming fish can be seen as they rise to the surface apparently attracted by the flare. Then comes the thrust, and the impaled fish is lifted out of the water passed toward the stern and released from the harpoon by the steersman where its flopping carcass is deposited in the bottom of the craft. When the salmon run is on a little flotilla of fishing canoes may be afloat in the pool engaged in this combined sport and food procurement."

Besides the true anadromous fishes, the salt-water trout (me'gwe adogwa'su) enters the mouth of rivers for the winter and spring seasons after the breeding season is over, and there they are captured by the Indians. Salmon, shad, herring, and gaspereau (the fresh-water herring) were formerly smoked for preservation, using the hard-woods for fuel. Very little of this is done today although fish are frequently salted. According to Denys (1908) the fishing canoes were made of slats of cedar covered with birch bark. The bark was sewed with roots of black spruce, and seams were sealed with spruce gum. Paddles were made of beech wood and a sail made from the skin of a moose calf. The fish were brought to shore and dried on gravel beaches and flakes. In winter time hook-and-line fishing was accomplished through holes cut in the ice.

In the fresh waters a number of aquatic vertebrates were also obtained. Eels (ga'dan) were pursued at night with spear and hook and line. Wallis (1922) mentions the use of the skin of this catadromous fish as a bandage. Whitefish and suckers (kɑm'kwet tu'pkwani) were also caught. Our informant never heard of the use of the bow (ha'bi·) and arrow (matc?'teli'gan) in catching fish such as are commonly employed by the Catawba Indians of South Carolina. In the ponds, frogs (Xato'wɑlan tcko'ltck = bullfrog; itcko'ltck = green frog) and toads of the larger species were gathered for eating the legs. Turtles (mikt-ci*tc), especially the snapping turtles, and their eggs were collected for food. The shell of the snapping turtle served as a container. Wallis (ibid.) lists turtle fat as a lubricant in the treatment of rheumatism. Reptile lore of the Northeastern aborigines has been treated in an earlier paper (Speck 1923)

The fresh-water clams were not eaten to the best knowledge of our informants. Neither is there any evidence from excavations that such ever played a part in the diet of coastal Indians. As the writers found to be the case with the Wampanoags of Massachusetts, the less desirable fresh-water clams did not attract the Indians because of the abundance and ease of obtaining salt-water shellfish.

Waterfowl, especially the ducks and geese (si'·nam = Canada goose; mɔ?ɑ̄lewi·tc = brant), and their eggs were taken for food. Other birds, listed by our informants from which the eggs were gathered, are the gulls, loons, shorebirds, and the great blue heron. Denys (1908) claimed that the Micmac ate all large birds and their eggs except the cormorant, and he added further that the feathers from the Canada goose were used in the making of robes. Water birds were hunted at night in a canoe with a birch-bark torch much as described for salmon fishing. Needles and awls were manufactured from the bones of birds, and bird feathers were used for ornamentation, such as the headdresses made of a few eagle feathers.

The aquatic mammals were of especial importance. Muskrat (ki'·wesu), otter (gi·unik), and beaver were trapped for food and hides. Robes were made from the fur of these three especially. Some were painted with a red dye extracted from the roots of small bedstraw (*Galium tinctorium*) (Denys 1908). Speck and Eiseley (1939) and Cooper (1939) described the conservation of beaver by the Northeastern Indians. By proper management they maintained a rather stable population of beaver at selected sites.

In the late fall and winter seasons hunting and trapping pursuits claimed the attention of the Micmac. At these times the game was in the best condition, and the pestiferous insects so severe in the summer season are not present. The Indians went inland for hunting at this time

(Piers, 1912). The physical and biological environment of the mixed hardwood and coniferous forests of the Northeast is succinctly summarized by Byers (1946), who pointed out that nearly all animal life available was taken in the hunting and trapping activities of the Northeastern area in early times. Denys (1908) has related that hunting was the chief occupation of men and the main source of food in the winter time, and at the funeral of a hunter mourners recited the animals which the hunter had killed in the chase. The upland hunting economy was based upon the family hunting ground system and an understanding of ecological principles of game populations, their relationship to the environment, and the balance of nature (Speck, 1915b; Speck and Eiseley, 1939; Cooper, 1939; and Hallowell, 1949). Authorities agree that this system is pre-Columbian in origin. At one time the woodland caribou was of special importance in the life of the Northeast Indian. It was an important source of both food and hides. According to Byers (1946), the stomach contents of the caribou as well as the flesh were eaten by the Indians. Dice used in their games were made from the bone of caribou (Hagar, 1895); scrapers and knives were prepared from the ribs (Elder, 1871). The caribou was hunted on snowshoes made with frames of ash or beech, corded with moose skin or animal intestines, and bow and arrows made from rock maple. Trumpets for calling the animals were made of birch bark. Dogs were used in hunting in which the object was to drive the caribou into deep snow so that the Indians could easily capture and kill them. Ward (1878) has described in detail this method of caribou hunting. The caribou is now extirpated from the New Brunswick region, but is still remembered by the older Indians. Next to the caribou, moose was the most important big game animal. The tongue and nose of the moose were considered a special delicacy for food. Grease was boiled out of the bones. The hides were used in the manufacturing of moccasins. According to Denys (1908) clothing, stockings, shoes, and bed coverings were made from moose hide, and the bones were made into pipes. Le Clercq (1910) mentions that the dew claws were used for rattles. Smith and Wintemberg (1929) described chisels made from the antlers, pendants from the incisor teeth, and perforated toe bones that were probably used in games. The skins of these large animals were used for tent coverings as well as for clothing. Some of the meat was dried and stored and the intestines were stuffed. The meat was cooked in the trough of a log filled with water into which hot stones were dropped for heating. Apparently all parts of these large game animals were used for something.

Some believe that the white-tailed deer or Virginia deer (li'ntuk) was not present in New Brunswick when white men arrived, but after the woodland caribou was decimated, the deer came into this area (Byers, 1946). However, Smith and Wintemberg reported deer bones (possibly caribou mistaken for deer?) in shell heaps of Nova Scotia which had been adapted by the Indians for use as awls. In any case, this large game animal has taken the place of the caribou in modern times. The black bear (mu'win) was another one of the large forest animals pursued by the prehistoric Micmac for both food and hides. Pendants were made from bear's teeth. The bear was one of the most popular animals mentioned in the folklore of these people. Hagar (1896) stated that this animal was believed to possess the greatest magical powers of all the animals known to the Indians.

Of the smaller forest game, the porcupine (ma'dawes) was one of the most useful from the point of view of the variety of its contributions to the economy of these Indians. The flesh was eaten and the quills were used for decoration on birch-bark vessels and on clothing prepared from animal skins. The quills were dyed red with a dye obtained from the roots of small bedstraw. Pottery has been found (Smith and Wintemberg, 1929) which is believed to be impressed with woven porcupine quills. Wallis (1922) claims that urine from the porcupine bladder was used in the treatment of hearing defects, and the fatty oil of this animal was used as a physic for newborn children. The importance of this animal easily explains why the Malecite referred to the Micmac as the "Porcupine Indians" (Matu-es-wi skitchi-nu-uk), according to the statement of Piers (1912). Other important upland game animals were the raccoon (amatci'·gwitc), snowshoe rabbit (wabus), woodchuck (mo'nɑmkwete), and the red and grey squirrels (a'dudwetc), all of which were used for food and fur. The skunk (abiktcilu), red fox, pine marten, fisher (ɑpᵉɑmp'k), mink (di·a'ge'ute), weasel (skᵉus), wolf (ba'XtɑžɑM), wolverine (ki'gwadju), and lynx were hunted for their pelts. Grease from many of these was also used in medicine (pi·sun); awls were

made from the ulna of the red fox and pendants from the teeth of the wolf (Smith and Wintemberg, 1929). Our informant spoke of five kinds of foxes, but they are all color phases of the red fox. According to Chamberlain (1884), the wolf was common between 1840–60, but it has since disappeared, and the wolverine was not found after the middle of the nineteenth century. In recent times these large carnivores, when they were extant, were killed largely as vermin. Perhaps the most important of the upland game birds was the Canada ruffed grouse (pɑla'wetc). Our informants were not familiar with the spruce grouse. In modern times the ring-necked pheasant has been introduced as it has been elsewhere in North America as a game bird. Denys (1908) included the crow and the robin in his listing of edible birds. The greak auk and the passenger pigeon were also hunted before they became extinct.

Hunting and trapping devices used by the Micmac are as follows: Bow and arrow, with the arrowhead of stone or bone; snare traps (nabot'a?an); the spring pole (haboɑwegan); dead falls (ni·si·aXlɔ'Xtegan); wooden clubs; stone axes; and knives made from the teeth of beaver. Snowshoes were used in winter hunting. The snowshoe cording frequently was made of the intestines of animals as were the strings on the bows. Dogs were regularly used in hunting. All observers seem to agree that all these primitive neolithic people of Northeastern North America probably utilized, especially for food, almost any animal that could be captured and that all edible portions were consumed, even the marrow of bones obtained by cracking open the large bones. Flannery (1946) claims that even cannibalism was practiced at one time by the eating of captives taken in war. In spite of their variety of diet and their practice of what we regard as conservation measures (MacLeod, 1936; Speck, 1938), there were times of famine among these hunting and fishing people.

Animal remains found in Micmac refuse heaps at various times and at various horizons include the following:

Moose	Raccoon	Rabbit	Dog	Fisher
Caribou	Porcupine	Seal	Wolf	Deer?
Bear	Squirrel	Whale	Red fox	
Muskrat	Woodchuck	Walrus	Lynx	

Also, the bones of many unidentified fish and birds have been found. Animal bones, however, are not nearly as common as the shells. Smith and Wintemberg (1929) believed that the relatively small number of fish bones was explained by the late development of fishing. Loomis and Young (1912), on the other hand, found fish bones in heaps on the Maine coast at the bottom. This was interpreted as a case of the Indians coming to the shore originally for fish, and later acquired the habit of eating shellfish. However, Witthoft (personal communication) has pointed out that fish do not leave such bulky waste as shellfish do, and actually fish bones occur throughout the Maine heaps.

Plant resources for the most part were secondary in importance, although plant products were of particular value in the diet during certain seasons. Halliday (1937) and Morison (1938) have outlined the forest types and enumerated the tree species of New Brunswick. The latter also gives a very good general description of the topography, geology, and climate of the region as well as the forests. From the standpoint of food, the sugar maple or rock maple tree is of greatest interest. Maple sugar (sna'wi·si·smo'gan) and maple syrup (sna'wi·mlas·is) were prepared from this tree dating back to prehistoric times. Denys (1908) explains that the sap was drawn off through porcupine quills. Henshaw (1890) has traced the early history of maple sugar manufacture by the American Indians. It has already been pointed out that wood from this tree was used in the manufacture of bows, polished with oyster and others shells.

From the standpoint of general utility, the canoe birch was undoubtedly of greatest significance. The wood was used in the manufacture of snowshoes and toboggans (Cooper, 1946) and the bark (ma'skwes) for the manufacture of canoes, house coverings, boxes, baskets, containers of various kinds, dishes, cooking utensils, and even coffins. It has been mentioned above that the bark was sewed with the roots of black spruce and often ornamented with porcupine quills. It will also be remembered that birch bark was used as a torch in night fishing and a birch-bark trumpet used for calling caribou and moose. Arrow shafts and canoe slats often came from white cedar. Black ash, more commonly called brown ash by the Indians, has been the most common source for basket splints in the manufacture of basketware. Red maple has similarly been used. In modern times sweetgrass has been introduced for the weaving of baskets and mats to take the place of rushes which were for-

merly used. White ash was used in the manufacture of axe and knife handles. The bark of alder, elm, and hemlock was used in the preparation of dyes. Stone (1932) described the chewing of alder bark for the treatment of wounds, fractures, and dislocations. Wood from the conifers was used for kindling and the hardwoods for fuel. Cooper (1946) stated that the wood of birch and conifers was preferred for cooking. Beds were made from the boughs of spruce and fir covered over with animal skins. The leaves of willow trees served as tobacco (tɑma′wi), and pipe stems were manufactured from willow twigs (Denys, 1908). The bark of certain trees was utilized in the making of drums, and inner bark of some trees (probably the pectin-rich bark of hemlock and pines) served as a famine food (Lescarbot 1928) and as a cure for scurvy. Hadlock (1947b) reported on woven mats which were probably made from bark of either red cedar (juniper) or arbor vitae (white cedar).

Wild fruits and berries known to have been gathered during the late summer and early fall seasons were as follows:

Blueberry	Elderberry	Crab apple
Huckleberry	Cranberry	Wild cherry
Strawberry	Partridgeberry	Choke cherry
Raspberry	Bearberry	
Blackberry	Black and red currants (gooseberries)	

Acorns (siste′gawet) and nuts were gathered from hazelnut, butternut, beech (beech nuts = swɔ′mussipᵉhan), and oak trees. Lescarbot (1928) mentions the gathering of peas along the seashore. Beverages were prepared from partridgeberries, labrador tea, muskrat root, sarsaparilla, and the bark from hemlock, white pine, black spruce, white spruce, balsam fir, rock maple, moosewood, and wild-cherry trees. Most of these beverages or teas were employed as medicines. Tubers of the wild potato (tɑb′ɑdɑnk), called artichokes by the Indians, were dug up for food. The dandelion (si·smɔ′ni mä′tɛkewe), since its introduction from Europe, has been gathered for greens just as it has been used by white man for the same purpose. The roots of gold thread and muskrat root or sweet flag (ki·we′swapskᵉ) were chewed for their medicinal value.

TABLE 1.—ANIMALS AND PLANTS UTILIZED BY THE MICMAC INDIANS, CHIEFLY FOR FOOD OR FOOD PROCUREMENT

Scientific Classification	English Name
PELECYPODA:	
Ostrea virginica	Oyster
Pecten grandis	Deep-sea scallop; giant scallop
Pecten islandicus	Scallop
Modiolus modiolus	Horse mussel
Mytilus edulis	Blue mussel; edible mussel
Spisula solidissima	Sea clam; hen clam
Mercenaria mercenaria	Quahog; hard-shell clam
Ensis directus	Razor clam
Mya arenaria	Soft-shell clam; long-neck clam
GASTROPODA:	
Cepaea hortensis	
Polinices heros	Sand-collar snail
Crepidula fornicata	Boat shell; slipper shell
Buccinum undatum	English whelk
CEPHALOPODA	Squid
ECHINODERMATA:	
Asteroidea	Starfish
Echinoidea	Sea-urchins
CRUSTACEA:	
Cragonidae	Shrimps
Homarus americanus	Lobster
Cancer irroratus	Rock crab
PISCES:	
Petromyzon marinus	Sea lamprey
Squalus acanthias	Spiny dogfish
Raja spp.	Skates
Acipenser oxyrhynchus	Sturgeon
Anguilla bostoniensis	Eel
Clupea harengus	Herring
Alosa sapidissima	Shad
Coregonus clupeaformis	Whitefish
Salmo salar	Atlantic salmon
Salvelinus fontinalis	Salt-water trout; brook trout
PISCES (Continued):	
Mallotus villosus	Capelin
Osmerus mordax	Smelt
Scomber scombrus	Mackerel
Roccus saxatilis	Striped bass
—?	Salt-water sunfish
Morone americana	White perch; sea perch
Sebastes marinus	Redfish; Norway haddock
Tautogolabrus adspersus	Cunner
Cottidae	Sculpins
Microgadus tomcod	Tomcod
Gadus morhua	Cod
Melanogrammus aeglifinus	Haddock
Hippoglossus hippoglossus	Halibut
Lophopsetta aquosa	Sand flounder
Pseudopleuronectes americanus	Winter flounder
Catastomidae	Suckers
Perca flavescens	Yellow perch
AMPHIBIA:	
Rana catesbiana	Bull frog
Rana clamitans	Green frog
REPTILIA:	
Chelydra serpentina	Snapping turtle
Chrysemys picta	Painted turtle
Cheloniidae; Dermochelidae	Sea turtles
AVES:	
Gavia immer	Loon
Ardea herodias	Great blue heron
Branta canadensis	Canada goose
Branta bernicla	Brant
Anatinae; Nyrocinae	Surface feeding and diving ducks

TABLE 1.—(*Continued*)

Scientific Classification	English Name
AVES (Continued):	
Bonasa umbellus	Ruffed grouse
Charadrioidea	Shorebirds
Larinae	Gulls
Plautus impennis	Great auk
Ectopistes migratorius	Passenger pigeon
Corvus brachyrhynchos	Crow
Turdus migratorius	Robin
MAMMALIA:	
Euarctos ameri anus	Black bear
Procyon lotor	Raccoon
Martes americana	Marten
Martes pennanti	Fisher
Mustela cicognani	Weasel
Mustela vision	Mink
Gulo luscus	Wolverine
Lutra canadensis	Otter
Mephitis mephitis	Skunk
Vulpes fulva	Red fox
Canis lycaon	Wolf
Lynx canadensis	Lynx
Phoca vitulina	Harbor seal
Phoca groenlandica	Greenland seal
Odobenus rosmarus	Walrus
Marmota monax	Woodchuck
Sciurus carolinensis	Gray squirrel
Castor canadensis	Beaver
Ondatra zibethica	Muskrat
Erethizon dorsatum	Porcupine
Lepus americanus	Snowshoe rabbit; varying hare
Odocoileus virginianus	White-tailed deer; Virginia deer
Alces americana	Moose
Rangifer caribou	Woodland caribou
Cetacea	Whales and porpoises
GYMNOSPERMAE:	
Pinus strobus	White pine
Larix laricina	Tamarack
Picea glauca	White spruce
Picea mariana	Black spruce
Abies balsamea	Balsam fir
Tsuga canadensis	Hemlock
GYMNOSPERMAE (Continued):	
Thuja occidentalis	White cedar; arborvitae
Juniperus spp.	Red cedar; juniper
ANGIOSPERMAE:	
Zostera marina	Eelgrass
Hierochloë odorata	Sweetgrass
Acorus calamus	Muskrat root; sweet flag
Salix spp.	Willows
Juglans cinerea	Butternut
Corylus sp	Hazelnut
Betula spp.	Birches
Betula papyrifera	Canoe birch; paper birch
Alnus spp.	Alder
Fagus grandifolia	Beech
Quercus spp.	Oaks
Coptis groenlandica	Goldthread
Ribes spp.	Currants; gooseberries
Pyrus coronaria	Crab apple
Crataegus spp.	Hawthorn
Fragaria virginiana	Strawberry
Rubus, spp.	Raspberries; blackberries; dewberries
Prunus spp.	Wild cherries; black cherries; beach plum; sand plum
Apios americana	Wild bean; groundnut
Acer pennsylvanicum	Moosewood; striped maple
Acer saccharum	Sugar maple; rock maple
Acer rubrum	Red maple
Aralia nudicaulis	Sarsaparilla
Ledum groenlandicum	Labrador-tea
Arctostaphylos alpina	Bearberry
Gaylussacia spp.	Huckleberries
Vaccinium spp.	Blueberries; cranberries
Fraxinus americana	White ash
Fraxinus nigra	Black ash; brown ash
Mitchella repens	Partridgeberry
Sambucus canadensis, S. pubens	Elderberries
Helianthus tuberosus	Artichoke; wild potato
Taraxacum officinale	Dandelion

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PALEONTOLOGY.—*New crinoids from the Pitkin of Oklahoma.* HARRELL L. STRIMPLE, Bartlesville, Okla. (Communicated by Alfred R. Loeblich, Jr.)

A prolific crinoid fauna has been discovered by Claude Bronaugh, of Afton, Okla., in the upper few feet of the Pitkin limestone formation in outcrops of the Cookson Hills southeast of Fort Gibson, Okla. Specimens have subsequently been collected by Mr. Bronaugh, Mrs. Hazel Bronaugh, Mrs. Melba Strimple, and the author on several field excursions. Several of the new forms are described below.

Telikosocrinus, n. gen.

Description.—Crown is of moderate length, expands rapidly. Dorsal cup composed of five small, upflared IBB, five large BB, five large RR, and three anal plates in normal (primitive) arrangement. Forty or more biserial arms are indicated. First bifurcation with the first primibrachial in each ray and a second branching with, or about, the fifth secundibrachial in all rays. Thereafter, the outer rays usually, but not always, continue to their termination without further bifurcation and the inner rays branch again. The next bifurcation normally takes place in only the outer arms and the fourth dichotomy, when present, occurs only in the ensuing inner rays.

Column is moderately pentagonal, pierced by a small pentalobate lumen. Anal tube terminates with a few irregular, upwardly or outwardly directed spinose plates.

Genotype.—Telikosocrinus caespes, n. sp.

Known range.—Chester, North America.

Remarks.—This genus has certain characteristics in common with *Pelecocrinus* Kirk (1941) and *Hydreionocrinus* de Koninck (1858). All three genera have more or less erect, cone-shaped dorsal cups with three anal plates in normal (primitive) arrangement. *Pelecocrinus* is readily separable in having a round stem, articulating facets which fail to fill distal faces of RR, uniserial arms, and 10 or more primibrachials above anterior radial. *Hydreionocrinus* is more difficult to distinguish and is probably closely related. The dorsal cup is shallow, interbasal sutures exceedingly short, or absent, and the biserial arms branch only in the inner rays after the second dichotomy.

The form described by Laudon (1941) as *Pelecocrinus stereosoma* from the middle Pitkin is reported to have uniserial arms with sporadic biserial development. Since the articulating facets of this species fill the distal faces of RR, and as there is no evidence of numerous PBrBr in the anterior ray, the species does not appear to belong with *Pelecocrinus.* It seems better assigned as *Telikosocrinus stereosma* (Laudon), n. comb.

Telikosocrinus caespes, n. sp.
Figs. 1–4

Description.—Crown moderately expanded, curving slightly inwardly at distal extremity and devoid of ornamentation. Dorsal cup high cone-shaped with a tendency toward a spherical outline. Sutures are mildly impressed giving cup plates a tumid appearance. Five IBB extend beyond the columnar scar and are visible in side view of the dorsal cup. Five BB are fairly large and five RR are wide, substantial plates. Three anal plates occupy the broad posterior interradius and are in primitive arrangement.

There are approximately 50 biserial arms. First PBrBr are wide, low, axillary and fill distal faces of RR. A biserial arrangement is rapidly attained by the SBrBr and second bifurcation takes place with the fifth to tenth SBrBr. In the holotype and most paratypes the outer rays remain unbranched and the next division of the inner rays takes place normally with about the ninth TBrBr. When another dichotomy occurs it is in an outer ray. A young paratype branches in either the outer or inner rays after the second dichotomy. Pinnules are delicate and not often preserved in place.

Anal sac is elongate, extending almost to the distal extremities of the rami. Several spinose, irregular plates mark the termination of the sac. Proximal columnals are mildly pentagonal and are alternately expanded. The lumen is pentalobate and small.

Measurements in mm.—As follows:

	Holotype	*Figured paratype*	*Paratype*
Height of crown	—	21.5	29.6
Height of dorsal cup	3.9	3.2	2.8
Maximum width of cup	10.2	7.2	9.7
Width of IBB circlet	5.2	2.7	2.8
Diameter of proximal columnal	2.7	1.9	2.0
Length of l. post. B[1]	3.2	1.5	2.1
Width of l. post. B	3.7	2.3	2.4
Length of interbasal suture[1]	1.2	0.5	0.9
Length of l. ant. R[1]	2.8	2.0	2.5
Width of l. ant. R	5.8	3.7	4.6
Length of interradial suture[1]	1.4	1.3	1.4
Height of PBr	2.9	2.2	2.8
Width of PBr	5.9	3.8	4.5

[1] Excluding consideration of surface curvature.

FIGS. 1–4.—*Telikosocrinus caespes*, n. gen. and sp.: 1, 2, Holotype from posterior and anterior, × 1.8; 3, 4, small paratype from anterior and posterior, × 1.7. FIGS. 5–9.—*Phanocrinus irregularis*, n. sp.: 5–7, Small paratype from posterior, anterior, and base, × 1.7; 8, 9, holotype from posterior and base, × 1.4. FIGS. 10–12.—*Phanocrinus modulus*, n. sp., holotype from posterior, base, and anterior, × 1.8. FIG. 13.—*Telikosocrinus residuus*, n. sp., holotype from posterior, × 1.7.

Remarks.—This species has a dorsal cup somewhat similar to that of *T. stereosoma* (Laudon); however, the IBB of the latter species are more pronounced and the cup is more elongate. *T. stereosoma* has primarily uniserial arms and a stronger tendency toward bifurcation in the outer rays after the second main dichotomy. Only one of six observed specimens of *T. caespes* showed any decided tendency toward bifurcation in the outer main rays after the second branching and all arms were biserial.

T. residuus has a more evenly expanded dorsal cup and the arms have a flattened exterior not found in *T. caespes.*

Occurrence and horizon.—Approximately 4 miles southeast of Greenleaf Lake, Cookson Hills, Okla.; upper Pitkin limestone formation, Chester, Mississippian.

Types.—Holotype and one paratype collected by Melba Strimple. Figured paratype collected by Claude Bronaugh. To be deposited in the U. S. National Museum.

Telikosocrinus residuus, n. sp.
Fig. 13

Description.—Crown is devoid of ornamentation, expands rapidly and evenly from columnar attachment. Dorsal cup cone-shaped, composed of five IBB, which are visible in side view of cup, five large BB, five large RR, and three anal plates. Posterior interradius is broad and plates are in normal (primitive) arrangement with RA resting obliquely against r. post. B and post. B, supporting RX above. Proximal edge of anal X is in broad contact with post. B and RA to the right.

There are approximately 50 arms indicated, exteriors flattened, biserial. First PBrBr low, axillary, fill distal faces of RR. Second bifurcation takes place with fourth or fifth SBrBr, thereafter, outer rays remain unbranched and inner rays branch with about the ninth TBrBr. After the third bifurcation the inner rays remain unbranched but the outer rays branch again on about the tenth or eleventh QBrBr. Pinnules are rather delicate and of moderate length.

Proximal columnal is large, pentagonal. Anal sac has not been observed except for the spinose terminating plates.

Measurements in mm.—As follows:

	Holotype
Height of dorsal cup	5.4
Maximum width of cup	13.9
Width of IBB circlet	5.8
Diameter of proximal columnal	3.8
Length of l. post. B	3.1
Width of l. post. B	4.3
Length of interbasal suture	1.7
Length of l. ant. R	3.0
Width of l. ant. R	5.5
Length of interradial suture	2.1
Height of PBr	3.2
Width of PBr	5.5

Remarks.—Comparison with *T. caespes* and *T. stereosoma* have already been given. *T. residuus* is closely comparable to *Hydreionocrinus woodianus* de Koninck (1858) in some respects. The dorsal cup of the latter species is shallower and the arms have a slightly different pattern in that after the third dichotomy the arms continue to bifurcate only in the innermost rays.

Occurrence and horizon.—Approximately 4 miles southeast of Greenleaf Lake, Cookson Hills, Okla.; upper Pitkin limestone formation, Chester, Mississippian.

Holotype.—Collected by Claude Bronaugh. To be deposited in the U. S. National Museum.

Genus **Phanocrinus** Kirk, 1941
Phanocrinus irregularis, n. sp.
Figs. 5-9

Description.—Crown elongate, tubular-shaped. Dorsal cup shallow, broad, base shallowly concave. Five IBB are small, confined to the basal concavity; five BB are large, distal extremities curved into basal concavity where they have broad median grooves; five RR are large, wide; and two small anal plates in posterior interradius. RA is in oblique but broad contact with post. B and supports the slightly larger anal X above.

Arms are 10, stout, uniserial, slow tapering. PBrBr are axillary, low, wide. First SBrBr are rather large tall plates but subsequent brachials are low broad plates. Pinnules are of moderate size.

Proximal columnals are round and pierced by a small pentalobate lumen. Tegmen is unknown. Entire crown is devoid of ornamentation.

Measurements in mm.—As follows:

	Holotype	*Figured paratype*
Height of crown	48.6	28.4
Height of dorsal cup	5.9	3.0
Maximum width of cup	16.8	11.2
Diameter of proximal columnal	2.1	1.7
Length of l. post. B^1	6.0	?
Width of l. post. B^1	5.1	3.7
Length of interbasal suture[1]	3.4	?
Length of r. ant. R^1	6.1	3.8
Width of r. ant. R^1	8.8	6.0
Length of interradial suture	3.0	2.5

	Holotype	*Figured paratype*
Height of PBr	4.1	4.4
Width of PBr	8.9	6.0

[1] Measurements along curvature of plates.

Remarks.—Only five specimens of *Phanocrinus* have been found in the horizon under study. Of these four are readily identified as *P. irregularis* and have the advanced arrangement of anal plates wherein RA has migrated to the dominant posterior position with anal X resting on the upper surface of RA, and RX has been entirely eliminated from the cup. It is considered significant that RA has also become small, thus indicating probable resorption. Such modification of the plates of the posterior interradius has been termed "Developmental Trend A" by the author (1948).

Phanocrinus cooksoni Laudon (1941) is closely comparable but has a higher cup with BB participating strongly in the outer walls of the dorsal cup.

Occurrence and horizon.—Approximately 4 miles southeast of Greenleaf Lake, Cookson Hills, Okla.; upper Pitkin, limestone formation, Mississippian.

Types.—Holotype and figured paratype collected by Melba Strimple. To be deposited in the U. S. National Museum.

Phanocrinus modulus, n. sp.
Figs. 10–12

Description.—Crown of moderate length, tubular-shaped, with distal extremity tapered to a point. Dorsal cup truncate bowl-shaped, with erect lateral sides. Five IBB are minute, confined to basal concavity and almost entirely covered by proximal columnals. Five BB large, curve strongly out of basal concavity to form a good portion of the lateral walls of the cup. Five RR large, only slightly wider than high. Three anal plates occupy the posterior interradius. RA is large, elongate, rests obliquely on post. B and r. post. B. Anal X is in contact with post. B but is strongly encroached upon by RA to the right. RX is in narrow contact with distal face of RA.

There are ten uniserial arms. PBrBr are large, axillary. SBrBr have strongly curved exteriors and are rather stout plates.

Proximal columnals are round, small, heavily crenulated. Tegmen is unknown.

Measurements in mm.—As follows:

	Holotype
Height of crown	20.1
Height of dorsal cup	3.6
Maximum width of cup	8.3
Diameter of proximal columnal	1.5
Length of l. post. B	4.8
Width of l. post. B	3.8
Length of interbasal suture	2.7
Length of r. ant. R	2.7
Width of r. ant. R	4.0
Length of interradial suture	1.8
Height of PBr	2.7
Width of PBr	4.0

Remarks.—*P. modulus* is a small species readily distinguished from other described species by the large RA, short stout arms and the outline of the dorsal cup in side view. The nature of the plates in the posterior interradius indicates modification toward "Developmental Trend B" as outlined by the author (1948), and is almost identical to figure 4 of that study.

Occurrence and horizon.—Approximately 4 miles southeast of Greenleaf Lake, Cookson Hills, Okla.; upper Pitkin limestone formation, Chester, Mississippian.

Holotype.—Collected by the author. To be deposited in the U. S. National Museum.

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ENTOMOLOGY.—Jordanopsylla allredi, *a new genus and species of flea from Utah (Siphonaptera).*[1]

ROBERT TRAUB, Major, MSC, and VERNON J. TIPTON, 1st Lt., MSC.

Under a research grant of the U. S. Public Health Service, Dr. D. E. Beck and Dorald M. Allred, of the Department of Entomology, Brigham Young University, have been conducting a survey of arthropods of potential medical importance in Utah. In the excellent collection of ectoparasites obtained by these workers is a remarkable flea here described as a new genus of the family Hystrichopsyllidae, subfamily Anomiopsyllinae.

Jordanopsylla, n. gen.

Diagnosis.—Unique in that the maxillary lobe is reduced, almost inapparent. Separated from all other genera in the family by the following combination of characters: Pronotal and genal combs both absent; unmodified terga with two rows of bristles. The only genus in the subfamily in which any of the following characters is present: A well-developed lateral metanotal area; a striarium on the second abdominal sternum; metatibiae with mesal bristles extending from base to apex; pleural arch distinct.

Description.—Clypeal tubercle absent. Preantennal region of head with one row of bristles. Postantennal region with but one row of bristles, and that marginal. Eye reduced. Apex of gena subangulate or somewhat rounded, not acuminate. Maxillary lobe (Fig. 1, *MX.*) weakly sclerotized, reduced, not acuminate. Apical segment of maxillary palpus about 3½ times as long as broad. Labial palpus (*L.P.*) very long, with apical segment arising distad of trochanter of forecoxa (*TR.*). Distal segment of labial palpus apically symmetrical, rounded. Pedicel of antenna normal, not ensheathing clavus. Bristles of pedicel longer than clavus (at least in female). Pronotum with one row of bristles; spines completely absent. Lateral metanotal area (Fig. 4, *L.M.*) broader than long. Pleural ridge of metasternosome fitting into a well-sclerotized socket (pleural arch) (*PL.A.*). Metanotum (*MTN.*) dorsally as long or longer than mesonotum (*MSN.*). Mesepisternum (*MPS.*) with anteroventral angle somewhat acuminate; without bristles. Metepisternum (*MTS.*) broad; dorsally convex; anterior margin evenly arcuate; with a long bristle; squamulum absent or vestigial. Metepimere (*MTM.*) free, not fused with metanotum; slightly broader than long. Procoxa with only approximately twelve lateral bristles (including marginals). Mesocoxae and metacoxae with thin mesal submarginal bristles scattered from base to apex. Tibial comb absent. Profemur with a few thin mesal bristles. Metatibia with approximately five dorsomarginal notches bearing paired bristles (including apical clump of three). First segment of metatarsus about two-thirds length of metatibia. All tarsi with but four pairs of plantar bristles on apical segment. Unmodified abdominal terga with first row of bristles distinct but reduced, not reaching spiracles. Striarium on second abdominal sternum well developed. Spiracles of metepimere subcylindrical, lacking a distinct ring; those of unmodified abdominal segments similar, but only about one-half the diameter. Some terga with apical spinelets. Female with one antepygidial bristle. Anal stylet with an apical long bristle; others greatly reduced. Female eighth sternum reduced, but with a few very small bristles. Ventral anal lobe (Fig. 3, *V.A.L.*, and Fig. 7) not angulate. Eighth sternum with submarginal mesal bristles. Bursa copulatrix (Fig. 3, *B.C.*) apically subspherical. Spermatheca (*SP.*) with tail longer than the subovate head.

Genotype: *Jordanopsylla allredi*, n. sp.

The genus is named for Dr. H. E. Karl Jordan, F. R. S., who, in his ninetieth year, is as cooperative and helpful as ever, and whose present contributions to the systematics of fleas are as outstanding as those which firmly established his reputation as dean of students of Siphonaptera.

Jordanopsylla allredi, n. sp.
Figs. 1–7

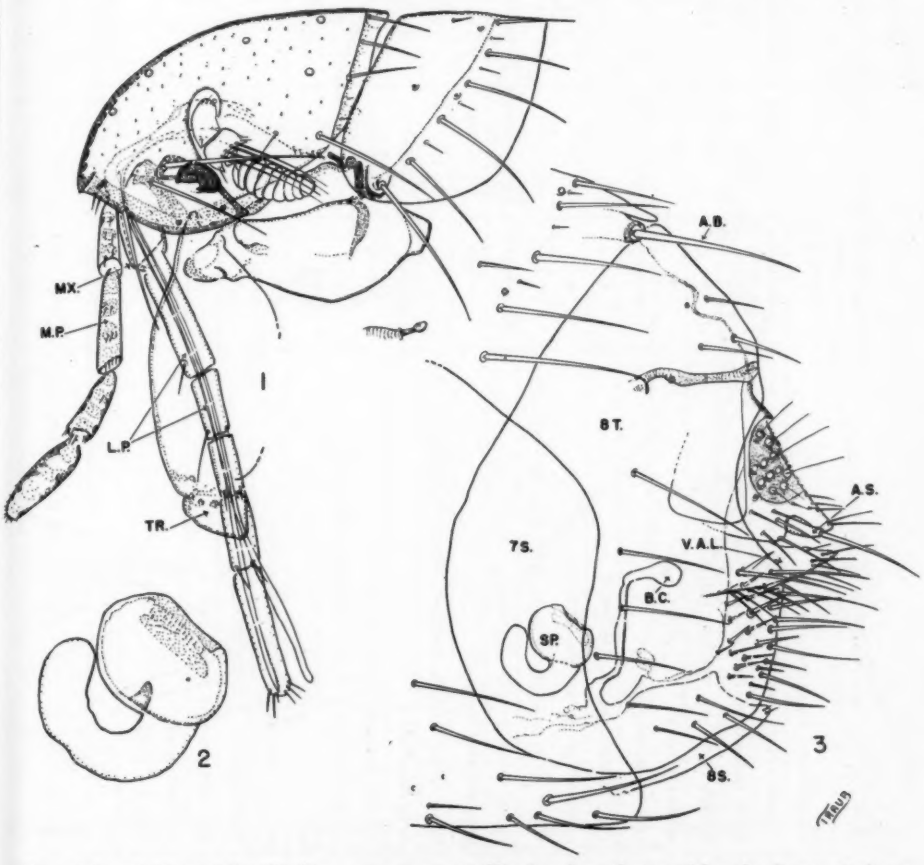
Types.—Holotype female ex *Peromyscus eremicus.* Utah: Washington County, Grafton, coll. D. E. Beck and D. M. Allred, Dec. 17, 1950. Deposited in collections of U. S. National Museum. Paratype female *ibid.*, but from Springdale, Nov. 4, 1950. In collection of senior author. Both specimens somewhat distorted. Male unknown.

Description.—HEAD (Fig. 1): Frontoclypeal region evenly rounded. Anteroventral angle some-

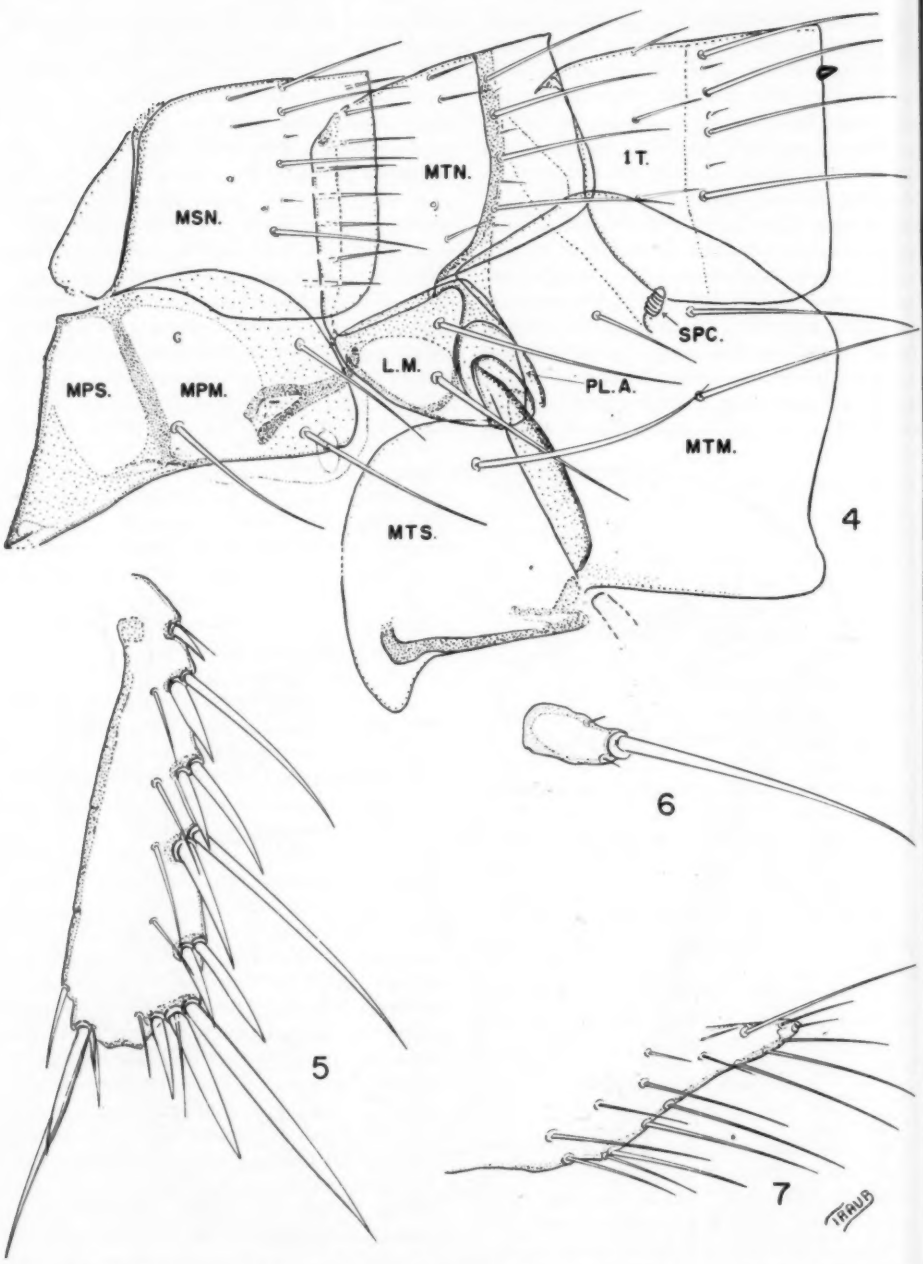
[1] Published under the auspices of the Surgeon General, Department of the Army, who does not necessarily assume responsibility for the professional opinions expressed by the authors.

what acuminate, resembling a diminutive snout. Micropunctations or pores scattered from margin to preantennal row of bristles; extending over most of postantennal region. Preantennal row with lowest bristle on genal margin just behind insertion of maxillary palpi (*M.P.*); middle bristle apparently of variable length but shorter than other two, inserted near uppermost, which is at level of reduced eye. Maxillary lobe (*MX.*) weak, apparently not extending beyond base of prementum; apically subrounded or subtruncate. Labial palpus (*L.P.*) with the last two segments completely extending beyond apex of procoxa. Pedicel of antenna with some short submarginal or marginal bristles, but with most marginals extending beyond apex of subovate club. Clavus almost twice as long as broad. Antennal fossa with five or six tiny dorsal hairs near caudal margin of head. Postantennal region with a fairly long ventromarginal bristle above middle of club; lowest bristle of marginal row at ventrocaudal angle, above vermiform vinculum; rest of row consisting of three fairly long bristles.

THORAX: Pronotal row with about five bristles on a side; with very small intercalary bristles between bases of larger ones. Mesonotum (Fig. 4, *MSN.*) with one complete row of bristles, with intercalaries and two subdorsal, more anterior, bristles; with about eight mesal pseudosetae on a side. Mesepisternum (*MPS.*) with ventral margin much broader than dorsal margin. Mesepimere (*MPM.*) caudally rounded, with a bristle in anteroventral region and two subcaudal ones. Metanotum (*MTN.*) with three bristles



FIGS. 1–3.—*Jordanopsylla allredi*, n. gen., n. sp.: 1, Head and prothorax of female; 2, spermatheca; 3, modified abdominal segments.



FIGS. 4–7.—*Jordanopsylla allredi*, n. gen., n. sp.: 4, Mesothorax, metathorax, and first tergum; 5, metatibia; 6, anal stylet; 7, ventral anal lobe.

m; 5,

TABLE 1.—COMPARATIVE TABLE: GENERA OF ANOMIOPSYLLINAE (FEMALES)

NO.	CHARACTER	JORDANOPSYLLA GEN. NOV.	ANOMIOPSYLLUS BAKER 1904	MEGARTHROGLOSSUS J.&R. 1915	CONORHINOPSYLLA STEWART 1930	CALLISTOPSYLLUS J.&R. 1915	STENISTOMERA ROTHS. 1915
1	CLYPEAL TUBERCLE	0	+	+	0	+	+
2	INTEGRECIPITATE	+	+	+	+	+	0
3	SOME HEAD BRISTLES SPINIFORM	0	0	0	0	0	+(0)
4	ANTEROVENTRAL ANGLE OF HEAD ACUMINATE	±	0	0	+	0	0
5	NUMBER ROWS OF PREANTENNAL BRISTLES	1	1(2)	1	2	2	4(5)
6	EYE	REDUCED	0	VESTIGIAL	VESTIGIAL (REDUCED)	0	0
7	PEDICEL ENLARGED, PARTIALLY ENSHEATHING CLAVUS	0	0	0	0	+	+
8	LENGTH OF BRISTLES ON PEDICEL	>CLAVUS	1/2 CLAVUS	SHORT	SHORT	AS LONG AS 1/2 CLAVUS	>CLAVUS
9	MAXILLARY LOBE	REDUCED	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
10	MAX'Y PALPI (SEGMENT 4)—RATIO: LENGTH TO BREADTH	3.5:1	5:1	5:1	6:1	4.5:1	3:1
11	POSTANTENNAL BRISTLES	0-1-ROW	0-0-ROW	1(0)-1-ROW	0-1-ROW	1-2-ROW	3 ROWS (1-ROW-ROW)
12	LABIAL PALPI—LENGTH (RE. LEG I)	FAR > TROCHANTERS	± TO TROCHANTERS	FAR > TROCHANTERS	> TROCHANTERS	±APEX COXAE	±APEX COXAE
13	LABIAL PALPI—RATIO: LENGTH OF ULTIMATE SEG'T. TO PENULTIMATE	2.3:1	1.5:1	2.5-3:1	1.5-2:1	2:1	± 1:1
14	LABIAL PALPI—NUMBER OF SEGMENTS	5	4	5	5-8	4	4
15	LABIAL PALPI—APEX SYMMETRICAL	+	±	0	0	±	±
16	APEX OF GENAL LOBE	SUBANGULATE	SUBROUNDED	SUBTRUNCATE	(SUBTRUNCATE) SUBROUNDED	ACUTE	SUBACUTE (ACUTE)
17	PRONOTAL COMB	0	0	+	+	+	+
18	NUMBER OF LATERAL BRISTLES ON PROCOXA*(±)	12	12	± 23	32	25	30-35
19	RATIO: MESONOTUM TO METANOTUM (DORSAL MARGIN)	1:1.1	1.6:1	1.5:1	1.8:1	1.8:1	1.8:1
20	ANTEROVENTRAL MARGIN OF MESEPISTERNUM (MPS.)	SUBACUTE	SUBTRUNCATE	SUBROUNDED	SUBROUNDED	SUBTRUNCATE	SUBTRUNCATE
21	PSEUDOSETAE ON MESONOTUM	+	0	+	+	+	+

+ = CHARACTER PRESENT OR APPLIES — = NOT APPLICABLE > = BEYOND, GREATER THAN ( ) = AN ALTERNATE CONDITION OR FIGURE
0 = CHARACTER ABSENT ± = SOMEWHAT, APPROXIMATELY * = INCLUDING MARGINALS

TABLE 2.—COMPARATIVE TABLE: GENERA OF ANOMIOPSYLLINAE (FEMALES)—Continued

NO.	CHARACTER	JORDANOPSYLLA GEN. NOV.	ANOMIOPSYLLUS BAKER 1904	MEGARTHROGLOSSUS J.&R. 1915	CONORHINOPSYLLA STEWART 1930	CALLISTOPSYLLUS J.&R. 1915	STENISTOMERA ROTHS. 1915
22	LATERAL METANOTAL AREA	+	0	+ (SMALL)	+ (SMALL)	0	0
23	BRISTLE(S) ON LATERAL METANOTAL AREA	+	–	+	0	–	–
24	PLEURAL ARCH	+	0	0	0 (VESTIGIAL)	0	0
25	UPPER ANTERIOR MARGIN METEPISTERNUM (MTS.) CONCAVE	0	+	+	+	+	+
26	RATIO: DORSAL MARGIN METEPISTERNUM TO METANOTUM	1:1.7	1:3.2	1:2.3	1:2.4	1:2.6	1:6–8.5
27	BRISTLE ON METEPISTERNUM (MTS.)	+	+	+	+	0	0
28	MTS. WITH MARGINAL INTERNAL TUBERCLE (SQUAMULUM)	0 (VESTIGIAL)	+	+	+	+	+
29	METEPISTERNUM WITH DORSAL MARGIN CONVEX	+	±	0	0	0	0
30	SHAPE OF SPIRACLE OF METEPIMERE (FIG. 4, SPC.)	± CYLINDRICAL	± SPHERICAL	± SPHERICAL	OBLATE	± SPHERICAL	± SPHERICAL (OBLATE)
31	SHAPE OF SPIRACLE OF SECOND ABDOMINAL SEGMENT	± CYLINDRICAL	± SPHERICAL	± SPHERICAL	OVATE	± SPHERICAL	± SPHERICAL (OVATE)
32	RATIO: DIAMETER OF SPIRACLES, ITEM 30: ITEM 31	1.2:1	2:1	2:1	2:1	2:1	2:1
33	METEPIMERE — FUSION WITH METANOTUM	FREE	FUSED	FUSED	FUSED	FUSED	FUSED
34	MESOTIBIA WITH COMB OF DORSOLATERAL BRISTLES	0	0	0	0	0	+
35	RATIO: METATIBIAL LENGTH TO METATARSUS I	1.6:1	±1.4:1	1.5:1	1.5:1	1.1:1	0.9:1
36	COXAE II & III WITH MESAL BRISTLES, FROM BASE TO APEX	+	0	0	0	0	0
37	COXAE II & III WITH CAUDOMARGINAL ACUMINATE SPUR	0	+	0	0	0	0
38	TARSI II — FIRST PAIR OF PLANTAR BRISTLES	ABSENT	DISPLACED (ABSENT ON III)	DISPLACED	DISPLACED	DISPLACED	DISPLACED
39	STRIARIUM ON ABDOMINAL SEGMENT II	+	0	0	0	0	0
40	NUMBER OF TERGAL ROWS OF BRISTLES	2	1	1	2	1	1
41	TOTAL NO. (±) APICAL SPINELETS – TERGA I–III	3(2)-2-0	6-2-0	2-0-0	6-3(2)-2	7-3-0	6-0(2)-0
42	NUMBER OF ANTEPYGIDIAL BRISTLES (♀)	1	1	3	3	3	3

+ = CHARACTER PRESENT OR APPLIES
0 = CHARACTER ABSENT
– = NOT APPLICABLE
± = SOMEWHAT, APPROXIMATELY
> = BEYOND, GREATER THAN
* = INCLUDING MARGINALS
( ) = AN ALTERNATE CONDITION OR FIGURE

preceding a row of four long bristles; the row with intercalaries. Lateral metanotal area (*L.M.*) with margins well sclerotized; subcordate (including region overlapping pleural arch); pitched or inclined slightly forward and upward; with two large bristles. Metepisternum (*MTS.*) slightly broader than long; with a long bristle near posterodorsal angle. Pleural arch (*PL.A.*) well developed, approximately twice as broad as long. Metepimere (*MTM.*) with about three bristles.

LEGS: Procoxa with about 12 lateral bristles, including marginals. Mesocoxae and metacoxae with fewer such bristles, but with one and two rows, respectively, of thin mesal bristles near anterior margin. Metatibia (Fig. 5) without mesal bristles. Femur with one or two lateral median bristles and a mesal row of thin bristles. None of bristles of hindtibia longer than length of segment. Measurements of tibiae and segments of tarsi (petiolate base deleted) of holotype shown in microns:

		Tarsal Segments				
Leg	*Tibia*	I	II	III	IV	V
Pro-	150	55	55	50	45	105
Meso-	275	90	110	70	50	120
Meta-	375	255	150	90	50	130

Second segment of metatarsus with two apical bristles extending distad of apex of fourth segment.

ABDOMEN: First tergum (Fig. 4, *1T.*) with two or three bristles preceding a full row; with one or two apical spinelets per side. Basal sternum with four bristles, the uppermost above the striarium. Unmodified terga with lowest bristle of first row not inserted below third bristle of second row; the second row with intercalaries. Unmodified sterna with about two ventral bristles. Seventh sternum (Fig. 3, *7S.*) with caudal margin broadly and shallowly concave; with about five longish bristles in an oblique row and three ventromarginal ones in a line with lowest of oblique row; with a few smaller submarginal bristles above first of the ventral row. Eighth tergum (*8T.*) with only about three short bristles above the vermiform spiracle; with three irregular but vertical rows of bristles below the ventral anal lobe, some of those of the first two rows actually mesal; the marginal bristles the longest; with four long median bristles and about five subventral. Eighth sternum reduced, but apparent, with two short apical hairs. Anal stylet (*A.S.* and Fig. 6) somewhat more than twice as long as broad; with a long apical bristle and perhaps a vestigial dorsal and ventral one. Ventral anal lobe (*V.A.L.* and Fig. 7) not heavily sclerotized; caudally slightly concave; with long thin marginal bristles and submarginals which are usually shorter. Spermatheca (*SP.* and Fig. 2) with head ovate, broader than long; tail upturned but not extending beyond head. Bursa copulatrix (*B.C.*) angled subapically, the apex subglobose, the proximal portion quite straight and fairly well sclerotized.

Comment.—The species is named for one of the collectors, Dorald M. Allred, who is contributing a great deal toward our knowledge of the Utah ectoparasite fauna.

AFFINITIES OF JORDANOPSYLLA

Many of the features that this genus possesses in common with certain other genera in the family, e. g., the marked reduction in chaetotaxy and the elongate stylets, are probably due to convergent evolution. It has been pointed out elsewhere (Traub, 1950; Traub, in press) that some of these features are considered characteristic of fleas which ordinarily are restricted to the nests of the hosts. Holland (1949) is also of the opinion that certain of these genera are nest-inhabiting forms. The reduction of the maxillary lobe in *Jordanopsylla* is probably an evolutionary step for a parasite which feeds when the host is sleeping, just as "sticktight" fleas with stout teeth on the hyperdeveloped stylets (e.g., *Hectopsylla* and *Rhynchopsyllus*) tend to have poorly developed labial palpi.

This new genus differs in a number of respects from other members of the subfamily Anomiopsyllinae. Further, these differences are of a greater degree than those between the other genera. Tables 1 and 2 list and compare salient generic characters found in females of Anomiopsyllinae (*Jordanopsylla*, *Anomiopsyllus*, *Megarthroglossus*, *Conorhinopsylla*, *Callistopsyllus*, and *Stenistomera*). It will be seen that, in addition to the characters presented in the generic diagnosis above, *Jordanopsylla* is the only member of the subfamily in which: the metepimere is free; the pleural arch is present; the upper margin of the metepisternum is convex; and the internal marginal tubercle of the metepisternum is vestigial. It is felt that this genus represents a new tribe, which may be characterized as follows:

Jordanopsyllini, n. tribe

Clypeal tubercle absent. Integrecipitate. Maxillary lobe reduced. Labial palpus elongate, extending beyond trochanter. Bristles on procoxa reduced in number; mesocoxa and metacoxa with a full vertical row of mesal bristles. Mesonotum subequal to metanotum in breadth. Lateral metanotal area prominent, well demarcated. Metepisternum with anterior and dorsal margins convex, not reduced. Typical spiracles subcylindrical. Metepimere not fused with metanotum. With a striarium on basal sternum. One antepygidial bristle in female.

ACKNOWLEDGEMENTS

Dr. Karl Jordan, of the British Museum, Tring, kindly verified the tribal and generic status of this flea. We are indebted also to Miss Phyllis Johnson, Army Medical Service Graduate School, Washington, D. C., for critical review of the manuscript.

LIST OF ABBREVIATIONS

A.B. Antepygidial bristle
A.S. Anal stylet
B.C. Bursa copulatrix
L.P. Labial palpus
L.M. Lateral metanotal area
MX. Maxillary lobe
M.P. Maxillary palpus
MPM. Mesepimere
MPS. Mesepisternum
MSN. Mesonotum
MTN. Metanotum
MTM. Metepimere
MTS. Metepisternum
PL.A. Pleural arch of metathorax
SP. Spermatheca
SPC. Spiracle
TR. Trochanter
V.A.L. Ventral anal lobe of proctiger
7*S.* Seventh sternum
1*T.* First tergum
8*T.* Eighth tergum

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ZOOLOGY.—*A luminescent new xystodesmid milliped from California.* H. F. LOOMIS, Coconut Grove, Fla., and DEMOREST DAVENPORT, University of California, Santa Barbara College, Santa Barbara, Calif.

A luminescent milliped has been discovered in central California. While luminescent chilopods have been reported, the question of self-luminous diplopods is still uncertain. There are several references in entomological literature to luminescent creatures that may or may not have belonged to this group or that may have been infected with luminous bacteria.

In 1949 a field party of plant ecologists in the mountains of Tulare County, Calif., first observed this handsome species at night near their camp and gathered living specimens, which were turned over to the junior author, who made various observations on them and sent preserved specimens to the senior author.[1] Unfortunately, all specimens were females and impossible to identify beyond placement in the family Xystodesmidae, but a collection made a year later for the purpose of gathering males was successful. Taxonomic study of these specimens shows they unquestionably represent an undescribed species and genus with several outstanding structural peculiarities in addition to the phenominal one of being the first authenticated luminescent milliped.

[1] Our thanks are due Dr. E. N. Harvey, Princeton University, Princeton, N. J., for being instrumental in bringing about the collaboration on the present paper.

Luminodesmus, n. gen.

Gentotype.—*Luminodesmus sequoiae*, n. sp.

Diagnosis.—Obviously related to the genus *Motyxia* Chamberlin but with more complicated gonopods, there being a fourth ramus, whereas *Motyxia* has but three; the dorsal tuberculation shows the greatest development of any known xystodesmid. A tendency to tuberculation has been observed in a few of the other species but the majority of them lack this form of sculpture.

Description.—Body of average size for the family or larger; both sexes strongly convex above. Segments 2, 3, and 4 with lateral carinae

directed forward, those of segments 5 to 15 projecting outward, while on segments 16 to 19 they are caudally produced; posterior corners of all segments rounded except those of segment 19, which has them reduced in size but bluntly acute. On segment 1 a few scattered raised pustules usually are evident, but they are more evident and numerous on the succeeding segments, and from segment 9 or 10 backward distinct scattered pustules are present on the sides of the dorsum and in a continuous series close to the posterior margin, on segments 17 to 19 there being 14 to 20 tubercules in this series. First joint of legs produced distally below into a short, blunt, conic lobe; second joint with a distal, slender, very acute, spinelike lobe half as long as the joint. Males with a pair of high conic sternal processes between the fourth legs, these lacking in the female, but on the sterna of both sexes thereafter a process is present adjacent to each coxa, the posterior pair of each sternum being most prominent especially on the posterior segments. Gonopods with long basal joint, the outer half of the terminal joint composed of four very dissimilar divisions or branches. Claws on anterior legs of the males not differing from those of the female, being neither enlarged nor abruptly curved beyond middle.

Luminodesmus sequoiae, n. sp.

Two males, one the type, and several females collected May 12–14, 1950, at campground directly above Camp Nelson at the juncture of Belknap Creek and the south fork of the middle fork of Tule River, Sequoia National Forest, Tulare County, Calif., at an altitude of approximately 5,000 feet. Paratype females from same locality collected in mid-May 1949. The species was found at the lower limits of the Sequoia zone, where these giant trees were associated with *Pinus*, *Libocedrus*, *Quercus*, and *Acer*. The hardwood lower story of this association provided a relatively moist leafy litter in which many of the animals were collected.

Male type and paratype females deposited in the U. S. National Museum. Male and female paratypes deposited in the University of California, Berkeley, and female paratypes in the California Academy of Sciences, San Francisco.

Description.—Width of the largest specimen, a female, 7.5 mm; the living color light pinkish tan, more pronounced on lateral carinae, a dark internal structure showing through the body-wall down the center of the dorsum. Opening through which the gonopods project transversely lenticular-triangular in shape, the posterior margin broadly and evenly rounded from side to side and thinly elevated high above the adjacent surface; anterior margin on each side oblique, meeting at a distinct angle at the midline of the body, the margin flat, not elevated above the adjacent surface. Gonopod as shown in the accompanying figure except that none of the basal hairs have been drawn.

Remarks.—This interesting species may occur in great numbers; it was possible to collect dozens of animals in the immediate vicinity of the campground at the type locality where, at night, they provided a striking display of luminescence. The appendages of the head, the legs, the margins of the terga, and the thin intersegmental junctures gave a pale greenish fire, the undulations of which were particularly striking when the animal was in motion. The source of the luminescence has not as yet been determined. The light is under no voluntary control on the part of the animal; it persists in daylight (subjection to darkness is not necessary for its appearance), and its source is fluorescent, as subjection of animals during daylight to ultraviolet light has demonstrated.

The function of luminescence in most creatures is to attract either the opposite sex or food. Since it appears that neither of these objectives can apply to this milliped, the members of its order being blind and all diplopods subsisting only on vegetable matter, the part luminescence plays in the life history of this species is problematical.

FIG. 1.—*Luminodesmus sequoiae*, n. gen. and sp.: Distal joint of left gonopod.

In the winter of 1932, W. B. Murbarger, of Kaweah, Calif., (in Tulare County about 30 miles north of Camp Nelson), sent specimens of a xystodesmid milliped to the Smithsonian Institution for identification, with the note that the animals were luminescent. Dr. O. F. Cook examined them and found all to be immature, impossible to identify, and requested additional specimens of Mr. Murbarger. These were sent, with a letter, on March 31, 1932, but apparently they also were young, for Dr. Cook, who was greatly interested in identifying the first known luminescent milliped and discussed it with the senior author, made no notes or comments on them, and no further attempts seem to have been made to secure adults.

Following identification of the foregoing Camp Nelson species, it now seems quite likely that Murbarger's specimens were *L. sequoiae*, and extracts from his two letters are of special interest. In his letter of February 24, 1932, he states that "these worms were taken beneath an oak tree and apparently were under no other trees in this locality (Kaweah, Tulare County, Calif.) Elev. about 3,000 feet. Their one peculiarity is that at night they are luminous and visible for some distance." When Dr. Cook requested additional specimens he mentioned that the emission of light by the animals might be limited to a particular season, but in replying on March 31, Murbarger wrote: "As to their emission of light being confined to certain seasons, I cannot say. I first noticed them the past December. At no time since then have they failed to be luminous in the dark. During the daytime they can only be found under moist boards, logs and the like but at night they seem to roam about in the leaves, under trees and like retreats. Regarding the color of living specimens, I have sketched the accompanying crude diagram. Younger ones are of a whiter, more transparent color, no yellow being present, but in all sizes and ages the dark line down the back is noticeable." In his very creditable sketch the first segment is indicated as being buff colored and the "back gray-yellow, shading to bright yellow on the serrated edge." If Murbarger's specimens actually were *L. sequoiae*, it appears that this species remains luminescent from December to mid-May at least.

ZOOLOGY.—*A new crayfish of the genus* Procambarus *from Louisiana, with a key to the species of the* Spiculifer *group.* HORTON H. HOBBS, JR., Miller School of Biology, University of Virginia. (Communicated by Fenner A. Chace, Jr.)

Three species of the *Spiculifer* Group (Hobbs, 1942:119) of the genus *Procambarus* have been described from the southern United States, and their combined ranges extend from eastern Louisiana to the Altamaha River drainage in Georgia; of the three, *P. spiculifer* (LeConte, 1856:401) has the largest range, having been reported from Mississippi, Alabama, Georgia, and northern Florida; *P. versutus* (Hagen, 1870:51) from Mississippi, Alabama, and Florida; *P. vioscai* Penn (1946:27) from Louisiana and Mississippi.

The species belonging to the *Spiculifer* group may be readily distinguished from the other members of the genus by possessing the combination of an areola less than 28 per cent of the entire length of the carapace, and two lateral spines on each side of carapace immediately caudad of the cervical groove.

Members of this group are all inhabitants of streams and are more abundant in those having a moderate current. Although there are few data available to indicate what factors in the environment limit their distribution to lotic situations, there is evidence that it is their inability to live in waters in which oxygen content is low. All these species have a broad areola (thus presumably a proportionally smaller gill chamber than do those species having a narrow one), and in American crayfishes, exclusive of the members of the genus *Cambarellus*, this feature is correlated with a lotic habitat. There is no evidence to suggest that the limiting factors in their ecological distribution are concerned with type of bottom, size of stream, pH, or hardness of the water, for both *spiculifer* and *versutus* have been taken from widely different types of streams.

The first specimens I saw of the species described below were collected by Percy Viosca from Talisheek, St. Tammany Parish, La., and have been deposited in the United States National Museum. Additional speci-

mens were sent to me by Dr. Edward C. Raney, of Cornell University, and I wish to thank him not only for these specimens but also for the many fine additions he has made to my collection.

I take great pleasure in naming this species in honor of Dr. George H. Penn, Jr., a mutual friend of Mr. Viosca's and mine, who has contributed much to our knowledge of the crayfishes of Louisiana.

Procambarus penni, n. sp.

Holotypic male, form I.—Body subovate, compressed laterally; abdomen longer than carapace (35.6–32.1 mm). Height of carapace slightly greater than width in region of caudodorsal margin of cervical groove (13.9–13.2 mm); greatest width of carapace a little cephalad of caudodorsal margin of cervical groove.

Areola relatively broad (4.2 times longer than wide) with four or five punctations in narrowest part. Cephalic section of carapace about 3.2 times as long as areola (length of areola about 23.6 per cent of entire length of carapace).

Rostrum long, excavate; sides subparallel to base of acumen which is set off by acute lateral spines. Acumen almost half as long as remainder of rostrum (5.0–11.4 mm). Margins of rostrum not swollen or conspicuously elevated. Upper surface bearing numerous small setae. Subrostral ridges poorly developed and not evident in dorsal aspect.

Postorbital ridges prominent, grooved laterad and terminating cephalad in acute spines. Suborbital angle almost obsolete, branchiostegal spine strong. Two strong acute lateral spines present on each side of carapace; upper surface of carapace punctate; lateral portion caudad of cervical groove granulate.

Cephalic section of telson with three spines in left and four in right caudolateral corners. Epistome with a small cephalomedian spine (see Fig. 8).

Antennules of the usual form with a strong acute spine present on ventral side of basal segment.

Antennae reaching caudad to middle of telson. Antennal scale long, of moderate width; widest cephalad of middle; outer distal margin with a strong spine.

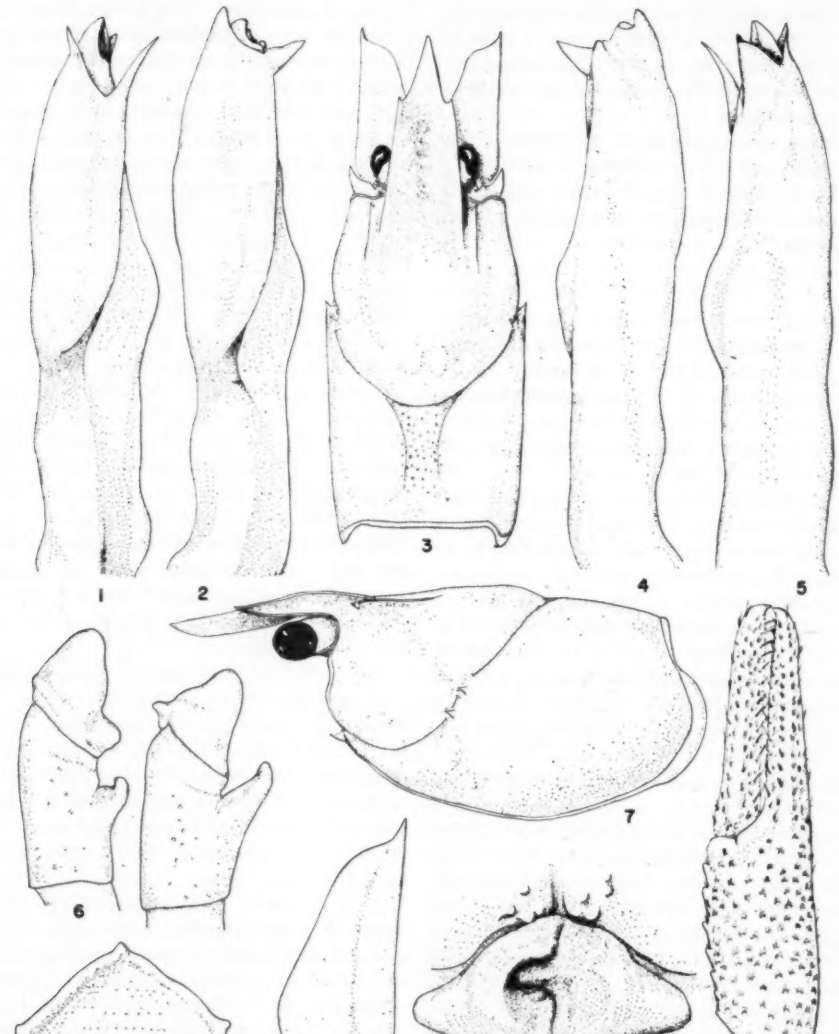
Chela subovate, somewhat depressed, long and slender. Hand entirely tuberculate; tubercles beset with conspicuous plumose setae. Inner margin of palm with a row of six tubercles, a prominent tubercle present on lower surface of palm at base of dactyl. Opposable surface of dactyl with four rounded tubercles on basal third, otherwise with crowded minute denticles; upper surface of dactyl with a few small setiferous tubercles at base, otherwise with setiferous punctations; lower and mesial surfaces similar to upper. Opposable margin of immovable finger with four tubercles on basal third and one large tubercle on lower opposable margin at midlength, otherwise entire opposable margin with minute denticles; other surfaces of finger with setiferous punctations. Both fingers with weak submedian ridges on upper and lower surfaces.

Carpus of first right pereiopod longer than wide (7.8 -4.3 mm), shorter than inner margin of palm of chela (10.3 mm), with a shallow oblique groove above. Surface mesiad of groove with two longitudinal rows of five subsquamous tubercles; surface laterad of groove with setiferous punctations; mesial surface with two spike-like tubercles and a few additional small and scattered ones; lateral and lower surfaces with setiferous punctations; distal margin of lower surface with two prominent spines.

Merus of first right pereiopod punctate laterad and proximomesiad; mesiodistal surface with small tubercles; laterodistal surface with an acute spine; upper surface with small tubercles, and near distal end with two spikelike tubercles. Lower surface with an outer row of nine tubercles, only three of which are conspicuous, and a mesial row of 15; a few additional small tubercles flank these two rows.

Hooks present on ischiopodites of third and fourth pereiopods; hooks on third long and slender and only slightly recurved; hooks on fourth somewhat more stocky and strongly recurved. Basipodite of fourth pereiopod with a swelling opposite hook on ischipodite. Coxopodites of fourth and fifth pereiopods with caudomesial projections: that on fourth heavy and inflated, that on fifth considerably smaller and somewhat compressed cephalocaudad.

First pleopod reaching cephalic side of coxopodite of third pereiopod when abdomen is flexed. Tip terminating in four distinct parts. Mesial process spiculiform and directed caudodistad. Cephalic process lying cephalomesiad of central projection, subacute, and extending slightly cephalomesiad. Caudal element consisting of three parts: caudal knob in lateral aspect acute



FIGS. 1–11.—*Procambarus penni*, n. sp.: 1, Mesial view of first pleopod of holotype; 2, mesial view of first pleopod of morphotype; 3, dorsal view of carapace of holotype; 4, lateral view of first pleopod of morphotype; 5, lateral view of first pleopod of holotype; 6, basipodites and ischiopodites of third and fourth pereiopods of holotype; 7, lateral view of carapace of holotype; 8, epistome of holotype; 9, antennal scale of holotype; 10, annulus ventralis of allotype; 11, upper view of carpus and chela of holotype. (Pubescence removed from all structures illustrated except in Fig. 11.)

and noncorneous; caudal process slender, sublanceolate, and excavate caudad; accessory process extends across the proximocaudal face of the caudal process and central projection as a thin corneous ridge. Central projection corneous truncate distad, with fusion line of its two components clearly marked.

Paratypic male, form II.—Similar in most respects to the holotype, except in the reduced secondary sexual characters and in the distribution of a few spines. First pleopod with all processes reduced and noncorneous; caudal and adventitious processes not distinguishable in the caudal element; caudal knob very prominent (see Fig. 4).

Allotypic female.—This specimen, although badly mutilated, is the only specimen in this collection in which the annulus ventralis contained a sperm plug. The annuli of the more perfect specimens appear somewhat underdeveloped; therefore I have chosen this specimen with the "mature" annulus as the allotype. Annulus ventralis with a submedian depression; sinus originates slightly dextrad of midventral line about one-third of the length of the annulus from cephalic margin, extends dextrad and makes a hair-pin turn to the midventral line where it turns caudad and terminates directly caudad of its origin just cephalad of caudal margin of annulus. Sternum cephalad of annulus deeply cleft along median line; on each side of median cleft is a swollen tuberculate prominence which extends caudoventrad and obscures extreme cephalolateral margins of annulus.

Measurement.—As follows (in millimeters):

	Holotype	*Allotype*	*Morphotype*
Carapace			
height	13.9	11.6	12.8
width	13.2	11.6	12.1
length	32.1	27.6	30.0
Areola			
length	7.6	6.3	7.3
width	1.9±	1.6	2.2
Rostrum			
length	11.4	10.3	10.7
width	5.1	4.7	5.1
Abdomen			
length	35.6	30.8	32.2
Right chela			
length of inner margin of palm	10.3	5.1	7.0
width of palm	6.0	3.7	4.8
length of outer margin of hand	25.0	13.5	18.3
length of dactyl	12.8	7.1	10.0

Type locality.—Talisheek Creek, at Talisheek, St. Tammany Parish, La., a tributary of the Pearl River. The creek is small (not more than 20 feet wide), spring-fed and sand-bottomed and rises in the longleaf-pine hills a short distance north of Talisheek. Here, for the most part, it is shallow with a few deep holes (4 or 5 feet deep). Vegetation is sparse, but debris collects in the holes and on the lee side of sandbars and behind logs.

The above information was kindly communicated to me by Dr. Penn, who consulted Mr. Viosca, the collector of the type specimens.

Disposition of types.—The holotypic male, the allotypic female, and the morphotypic male (nos. 91662, 91663, 91664) together with paratypes consisting of 6♂♂ II, 3♀♀, 2♂♂ immature, and 8♀♀ immature from the type locality are deposited in the United States National Museum. A series of paratypes (1♂ I, 3♂♂ II, 1♀, and 1♀ immature) collected from a tributary of Black Creek, 7.9 miles west of Hattiesburg, Lamar County, Miss., by Dr. E. C. Raney are in the collection of Dr. George H. Penn, Jr., Tulane University. The following paratypes are in my personal collection at the University of Virginia: HHH no. 3-3048-5a (1♂ I, 2♂♂ II, 7♀♀, 10♂♂ immature, and 7♀♀ immature) from a tributary of the Pearl River, 8 miles north of Angie, Marion County, Miss., on Route 7 [E. C. Raney, coll.]; HHH no. 6-1549-1 (2♂♂ I), 9.6 miles east of Franklinton, Washington Parish, La. [R. D. Suttkus, coll.].

Range.—Insofar as is known at present this species is confined to tributaries of the Pearl and Pascagoula Rivers in eastern Louisiana and south-central Mississippi.

Relationships.—*Procambarus penni* has its closest affinities with *P. vioscai* but may readily be distinguished from it by the more acute caudal process of the first pleopod of the first form male.

KEY TO THE SPECIES OF THE SPICULIFER GROUP

(Based on the first-form male)

1. Cephalic process of first pleopod rudimentary or lacking ..... *spiculifer*
   Cephalic process of first pleopod well developed 2
2. Mesial process of first pleopod terminating proximad of tip of caudal element; rostrum with median carina ..... *versutus*
   Mesial process of first pleopod extending beyond tip of caudal element; surface of rostrum concave 3
3. Mesial process extending caudolaterad; caudal knob rounded distally in lateral aspect. *vioscai*
   Mesial process extending caudodistad; caudal knob subacute in lateral aspect ..... *penni*

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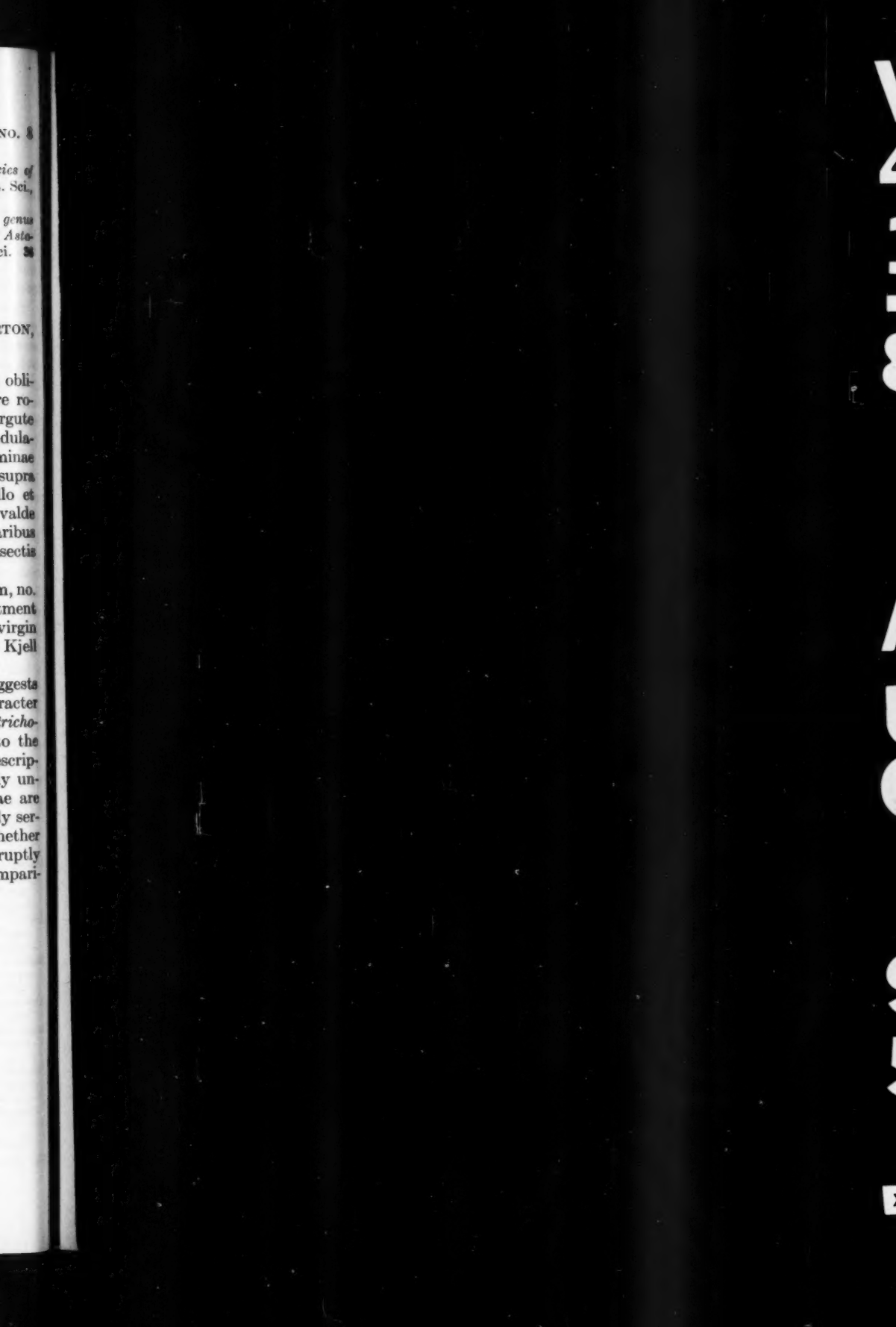
BOTANY.—*A new fern of the genus* Danaea *from Colombia.*[1] C. V. MORTON, U. S. National Museum.

The small genus *Danaea*, of the family Marattiaceae, is one of the few genera of ferns confined to the Western Hemisphere. It prefers to grow in moist, dark, tropical forests, where it is often one of the most conspicuous terrestrial plants. Because of the lack of clear morphological characters, the species are not well understood. One of the plants collected in Colombia by Kjell von Sneidern represents a new species, described below.

Danaea tenera Morton, sp. nov.

Rhizoma crassum, breviter repens, ca. 3.5 cm longum, 1 cm diam.; stipulae magnae, crassae, latae, integrae. Folia sterilia paripinnata, 22–30 cm longa, stipitibus crassis, 8–11 cm longis, 2–4 mm diam., inconspicue 2-nodosis, ubique dense paleaceis, paleis brunneis, minutissimis, suborbicularibus, denticulatis; rhachis compressa, supra nuda, subtus dense et minute brunneo-paleacea, utrinque perspicue viridi-alata, gemma terminata; pinnae tenuiter membranaceae, 12–14-jugae, breviter petiolulatae (1–2 mm), anguste oblongae, 4–6 cm longae, 10–15 mm. latae, apice gradatim acuminatae, basi obliquae, basi superiore cuneatae, inferiore rotundatae, apicem versus perspicue et argute uncinato-serratae, deorsum paulum undulatae; venae simplices vel plerumque geminae (raro furcatae), 12–14 per cm; lamina supra glabra et epaleacea, subtus mesophyllo et praecipue in costis paleacea, paleis valde diversis, alteris mediocribus, orbicularibus vel deltoideis, alteris minutissimis, dissectis vel piliformibus. Folia fertilia ignota.

Type in the U. S. National Herbarium, no. 1742723, collected at La Costa, Department of El Cauca, Colombia, April 1937, in virgin forest, at 1,000 meters elevation, by Kjell von Sneidern (no. 1578).

In its very thin texture *D. tenera* suggests the genus *Trichomanes*, and in this character recalls only *D. crispa* Endres and *D. trichomanoides* Moore. It may be related to the latter, but that species differs (from description) in having smaller, obtuse, merely undulate pinnae; in *D. tenera* the pinnae are long-acuminate and remarkably sharply serrate toward apex. It is not certain whether the leaves of *D. trichomanoides* are abruptly pinnate (as in the present species) or imparipinnate.

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